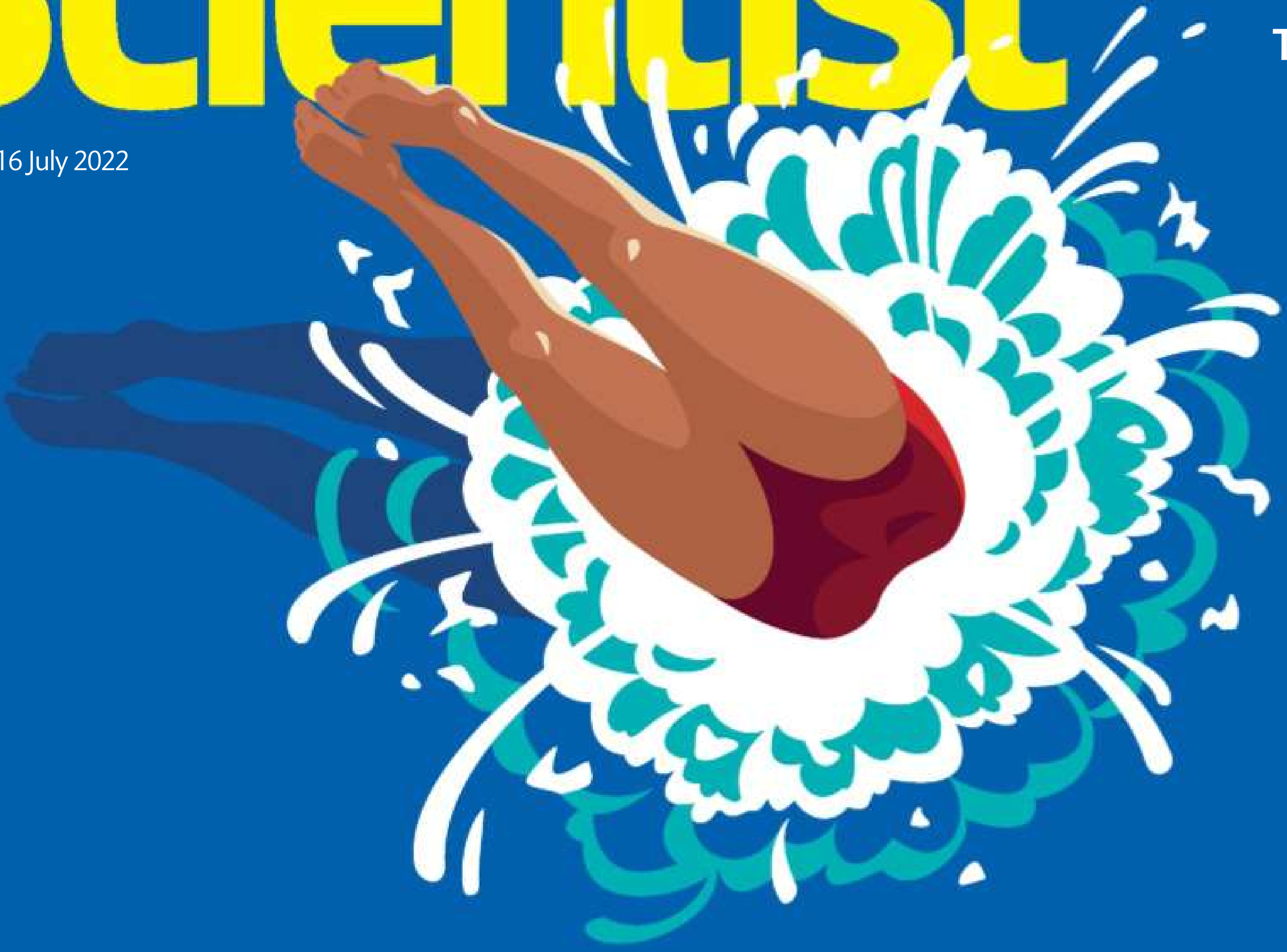
New Scientist

WEEKLY 16 July 2022

BILLIONS OF STARS
Space telescope's amazing new view of the universe

ILLOGICAL THINKING
DeepMind AI learns physics by watching nonsense videos

LOOPY MATHS
The surprising importance of untangling knots



BLUE THERAPY

The extraordinary benefits of time spent close to water

BEES v WASPS
A scientific showdown

No3395 £6.95 CAN$9.99

PLUS WHY MEN EAT MORE IN SUMMER / **THREE-EYED PREDATOR** / **RISK OF FALLING ROCKETS** / A GUIDE TO ROCK POOLING

abrdn

To invest with confidence, seek out experience.

abrdn
Investment Trusts

Now more than ever, investors want to know exactly what they're investing in.

abrdn investment trusts give you a range of 21 carefully crafted investment portfolios – each built on getting to know our investment universe through intensive first-hand research and engagement.

Across public companies, private equity, real estate and more, we deploy over 800 professionals globally to seek out opportunities that we think are truly world-class – from their financial potential to their environmental credentials.

Allowing us to build strategies we believe in. So you can build a portfolio you can rely on.

Please remember, the value of shares and the income from them can go down as well as up and you may get back less than the amount invested.

Request a brochure: 0808 500 4000

invtrusts.co.uk

Issued by Aberdeen Asset Managers Limited, registered in Scotland (SC108419) at 10 Queen's Terrace, Aberdeen, AB10 1XL, authorised and regulated in the UK by the Financial Conduct Authority. Please quote 2891.

This week's issue

On the cover

38 Blue therapy
The extraordinary benefits of time spent close to water

42 Bees v wasps
A scientific showdown

New Scientist

BLUE THERAPY

The extraordinary benefits of time spent close to water

BEES v WASPS

A scientific showdown

Vol 255 No 3395
Cover image: Stephen Millership

8 Billions of stars
Space telescope's amazing new view of the universe

14 Illogical thinking
DeepMind AI learns physics by watching nonsense videos

45 Loopy maths
The surprising importance of untangling knots

15 Why men eat more in summer
18 Three-eyed predator
15 Risk of falling rockets
48 A guide to rock pooling

38 Feature

> "Blue spaces often have patterns of change that you don't get with green spaces"

News

7 Omicron's third wave
Covid-19 is surging again in the UK and other countries

10 Scientists in limbo
Boris Johnson's resignation puts UK funding plan in doubt

12 Autonomous weapons
International efforts to regulate "killer robots" are faltering

Views

27 Comment
The illegal trade in birds must stop, says Raj Tawney

28 The columnist
A new UK coal mine would be wrong, says Adam Vaughan

30 Aperture
Grisly objects from a new exhibition on anatomical study

32 Letters
Changing seasons already take their toll on people

36 Culture
A new symphony makes music from black hole data

JOHN FINNEY PHOTOGRAPHY/GETTY IMAGES

20 Potential for growth Optimising genetics could double wheat yields

Features

38 Into the blue
Head to the water for the biggest benefits of nature

42 Bees v wasps
Who will come out on top in our scientific skirmish?

45 Knotty problem
How many knots exist?

48 Rock pooling for adults
Discover the beach's top secrets

The back pages

52 Stargazing at home
Pinpointing Pluto

53 Puzzles
Try our crossword, quick quiz and logic puzzle

54 *Almost* the last word
Could dinosaurs have developed human-like intelligence?

55 Tom Gauld for *New Scientist*
A cartoonist's take on the world

56 Feedback
Trolley trouble and where's the beef: the week in weird

Elsewhere on New Scientist

Academy

Gut health: How your microbiome shapes your health and well-being

In this CPD-accredited course, you will explore the latest scientific research about gut health, including powerful links between our gut microbes and our physical and mental well-being. You will also discover what actions you can take to shape your microbiome and improve your health. Sign up online:

academy.newscientist.com

NS Live

Schools' day

Calling all schoolchildren in the UK! Join us at schools' day at NS Live. We have 16 brilliant talks covering everything from video games to explosions to hacking your brain, and more than 80 interactive experiences designed to inspire and enthuse school groups aged 10 to 16. Schools' day takes place on Friday 7 October at ExCeL London.

live.newscientist.com

Podcast

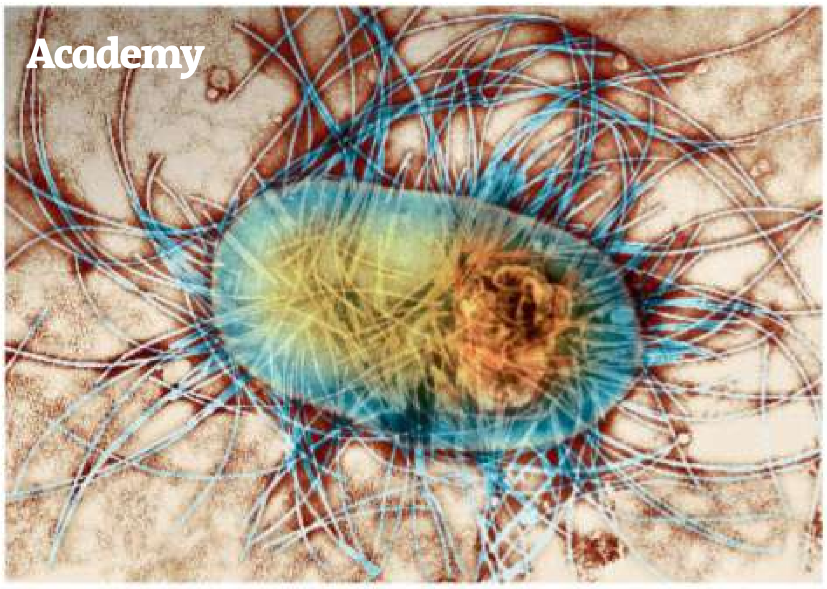
Weekly

How do large hawks land without crashing? Researchers have been exploring this question, and the team explains how their findings could help with innovations in drone technology. Plus, there is a time-travel paradox, fifth-wave coronavirus news and an interview about how to fight greenwashing with Maria-Krystyna Duval at law charity ClientEarth.

newscientist.com/nspod

ECOPIC/GETTY IMAGES

Soft landing Hawk acrobatics could help improve drone technology



UK HEALTH SECURITY AGENCY/SCIENCE PHOTO LIBRARY

Friendly bacteria How to shape your microbiome for better health

Video

Endangered species

Deep in the collections of the Field Museum in Chicago, Illinois, are examples of many extinct and endangered species from around the world. For nearly 15 years, photographer Marc Schlossman has been documenting this collection, drawing attention to the main culprits of biodiversity loss: climate change and habitat destruction.

youtube.com/newscientist

Newsletter

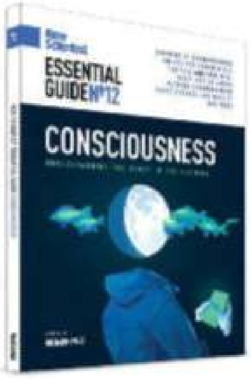
Lost in space-time

This week we hand the reins over to Sabine Hossenfelder, who specialises in probing our understanding of the foundations of physics and hosts the popular YouTube channel "Science without the gobbledygook". She explores a central tenet of quantum physics: can particles really be in two places at once?

newscientist.com/sign-up

Podcast

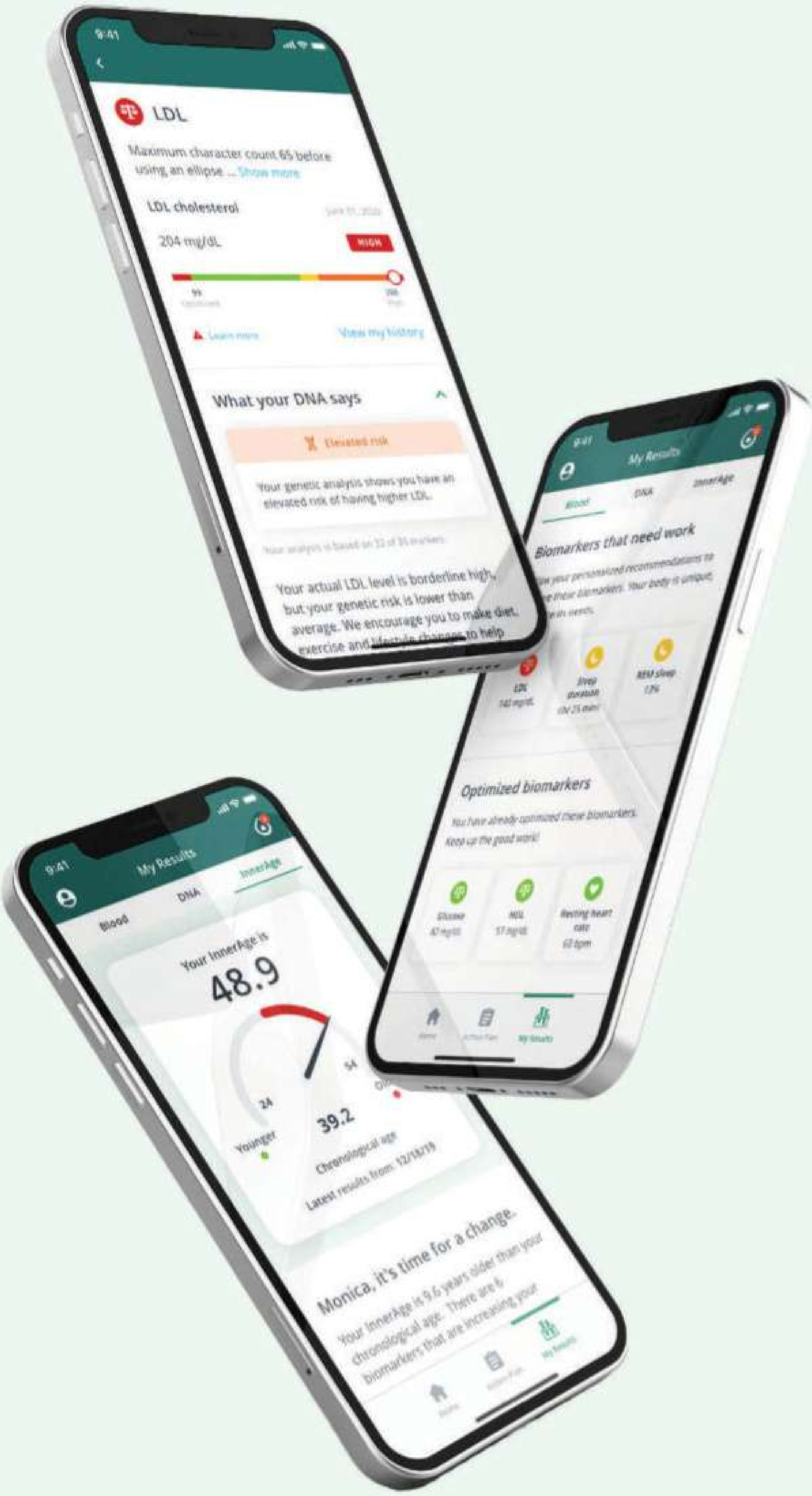
> **"There are more causal loops in universes with only one spatial dimension, so we should be fine"**



Essential guide

Consciousness is the ghost in our machine – our feeling of being and our relationship with the world. But what does it consist of and why do we have it? Delve into the ultimate mystery of being with the latest *New Scientist Essential Guide*.

shop.newscientist.com



Powered by A.I.

Our advanced, algorithmic engine uses information from your blood, DNA, and lifestyle habits—plus vast amounts of biometric and scientific data—to build your personalized Action Plan.

Validated by science

Our nutrition, fitness, and lifestyle recommendations are backed by the latest, peer-reviewed research in nutrition, genetics, and aging. Your Action Plan evolves with your body and continually updates based on the latest available science.

Driven by your data

InsideTracker does what one-size-fits-all nutrition plans can't: it uses your body's unique biomarkers to deliver truly personalized guidance that specifically addresses your individual health goals.

InsideTracker

InsideTracker is a truly personalized nutrition and performance system, created by leading scientists and researchers to help you live healthier, longer.

OCEAN SAVER®

SAVE *20% THIS PLASTIC FREE JULY

Refill is the new recycle.

SCAN TO SHOP

Save *20% when you buy any of the OceanSaver cleaning products, including the EcoDrops, when you use the code **SCIENTIST20**. The EcoDrops are plastic free, plant-based refills that make your plastic bottles reusable, helping to reduce plastic waste in your home - and the ocean. Find out more at **ocean-saver.com**.

DROP an EcoDrop into a spray bottle & fill with water

SHAKE until the EcoDrop has dissolved

CLEAN your home spotlessly!

*T&Cs: Offer does not apply to subscriptions, gift cards or donations and is valid 01.07.2022–31.07.2022. Offer can only be redeemed on ocean-saver.com and code **SCIENTIST20** must be entered at checkout for the discount to apply. Offer cannot be used in conjunction with any other discounts.

Forgotten, but not gone

We can curb covid-19 infection rates if we want to – but we can't do it without data

YOU may have heard that the coronavirus pandemic is over. This narrative is common and covid-19's ranking among international news agendas has fallen dramatically since the start of the year, displaced by a host of other stories, including war, Roe v Wade, food and energy crises, extreme heatwaves and a political soap opera in the UK government.

And yet there are now more confirmed cases of covid-19 globally than there were at any point during the first two years of the pandemic, as the BA.4 and BA.5 omicron subvariants spread worldwide and contribute to the UK's fifth wave of surging covid-19 infections (see page 7).

Due to cutbacks in mass testing, it is perhaps more difficult than ever to get a clear picture of the pandemic's current status. Fortunately, the randomised testing survey conducted by the UK's official statistics agency continues to give a picture of the country's infections – albeit with a roughly nine-day time lag in which infection numbers could peak, stabilise or rise dramatically without us knowing.

> "As ever-more-transmissible variants emerge, increasing infections mean more deaths"

The wide roll-out of vaccines in some countries has avoided many deaths – 20 million globally, according to one study. But the vaccines' protection against the coronavirus has never been 100 per cent, and as ever-more-transmissible variants continue to emerge, increasing infection numbers will always mean more deaths. Covid-19 was the underlying cause of 166 deaths in England and Wales in the week ending 24 June, the most recent official data available. Many questions about the virus also remain, ranging from the long-term effects it has on our organs to the impact of catching it multiple times.

No one wants to return to mass lockdowns. But two-and-a-half years of research has provided us with tools for curbing infections, from rapid testing and isolation to behaviour change and masking, as well as the knowledge that ventilation is crucial. To best deploy these valuable tools, we need a full, data-informed understanding of the current state of play. ▮

PUBLISHING & COMMERCIAL

Commercial and events director Adrian Newton

Display advertising
Tel +44 (0)203 615 6456 **Email** displayads@newscientist.com
Sales director Justin Viljoen
Account manager Matthew Belmoh
Account manager Mila Gantcheva
Partnerships account manager David Allard

Recruitment advertising
Tel +44 (0)203 615 6458 **Email** nssales@newscientist.com
Recruitment sales manager Viren Vadgama
Key account manager Deepak Wagjiani

New Scientist Events
Tel +44 (0)203 615 6554 **Email** live@newscientist.com
Sales director Jacqui McCarron
Head of event production Martin Davies
Head of product management (Events, Courses & Commercial Projects) Henry Gomm
Marketing manager Emiley Partington
Events and projects executive Georgia Peart
Production executive Isabella Springbett

New Scientist Discovery Tours
Director Kevin Currie

Marketing & Data
Marketing director Jo Adams
Director of performance marketing and audience development Jeffrey Baker
Head of campaign marketing James Nicholson
Head of customer experience Emma Robinson
Head of audience data Rachael Dunderdale
Data and analytics manager Ebun Rotimi
Senior email marketing executive Natalie Valls
Email marketing executive Ffion Evans
Digital marketing manager Jonathan Schnaider
Senior customer experience marketing manager Esha Bhabuta
Senior marketing executive Sahad Ahmed
Marketing assistant Charlotte Weeks

Digital Products
Digital product development director Laurence Taylor
Head of learning experience Finola Lang

Technology
Chief operations officer International Debora Brooksbank-Taylor
Technology director Tom McQuillan
Maria Moreno Garrido, Dan Pudsey, Amardeep Sian, Ben Townsend, Piotr Walków
Front end developer Damilola Aigoro
Junior front end developer Matthew Staines

NewScientist

Chief executive Nina Wright
Executive assistant Lorraine Lodge
Team administrator Olivia Abbott

Finance & operations
Chief financial officer Amee Dixon
Financial controller Taryn Skorjenko
Commercial finance manager Charlotte Thabit
Commercial finance manager Anna Labuz
Management accountant Charlie Robinson

Human resources
Human resources director Shirley Spencer
HR business partner Katy Le Poidevin

CONTACT US
newscientist.com/contact

General & media enquiries
UK **Tel**+44 (0)203 615 6500
Northcliffe House, 2 Derry Street, London, W8 5TT
Australia 58 Gipps Street, Collingwood, Victoria 3066
US PO Box 80247, Portland, OR 97280

UK Newsstand
Marketforce UK Ltd **Tel** +44 (0)33 0390 6555

Syndication
Tribune Content Agency **Tel** +44 (0)20 7588 7588
Email tca-articlesales@tribpub.com

Subscriptions
newscientist.com/subscription
One year print subscription (51 issues) UK £270
Tel +44 (0)330 333 9470
Email subscriptions@newscientist.com
Post New Scientist, Rockwood House, Perrymount Road,
Haywards Heath, West Sussex RH16 3DH

© 2022 New Scientist Ltd, England.

New Scientist is published weekly by New Scientist Ltd. ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Precision Colour Printing Ltd

EDITORIAL

Editor-in-chief Emily Wilson
Magazine editor Catherine de Lange
News and digital director Penny Sarchet
Creative director Craig Mackie

News
News editor Jacob Aron
Assistant news editors Chris Simms, Alexandra Thompson, Sam Wong
Reporters (UK) Michael Le Page, Matthew Sparkes, Adam Vaughan, Clare Wilson, (Aus) Alice Klein
Trainees Jason Arunn Murugesu, Alex Wilkins
Intern Carissa Wong

Digital
Audience editor Alexander McNamara
Podcast editor Rowan Hooper
Web team Emily Bates, Matt Hambly, Chen Ly, David Stock

Features
Deputy head of features Daniel Cossins, Helen Thomson
Editors Abigail Beall, Anna Demming, Kate Douglas, Alison George, Joshua Howgego
Feature writer Graham Lawton

Culture and Community
Comment and culture editor Alison Flood
Senior culture editor Liz Else

Subeditors
Chief subeditor Eleanor Parsons
Bethan Ackerley, Tom Campbell, Jon White
Trainee Tom Leslie

Design
Art editor Julia Lee
Joe Hetzel, Ryan Wills

Picture desk
Picture editor Helen Benians
Tim Boddy

Production
Production manager Joanne Keogh
Production coordinator Carl Latter

New Scientist US
US Editor Tiffany O'Callaghan
Editors Timothy Revell, Chelsea Whyte
Reporters Leah Crane, James Dinneen, Jeremy Hsu, Karmela Padavic-Callaghan, Grace Wade, Corryn Wetzel
Subeditor Alexis Wnuk

NewScientist
ESSENTIAL GUIDES

SUBSCRIBE FOR ONLY £49.95 A YEAR

NEW SCIENTIST
ESSENTIAL GUIDES
DELIVERED DIRECT TO YOUR DOOR

Based on the best coverage from *New Scientist*, the *Essential Guides* are comprehensive, need-to-know compendiums covering the most exciting themes in science and technology today.

Get the series, including the latest issue on Consciousness, with an *Essential Guides* subscription. It means you don't have to search for issues in the shops – we can deliver them direct to your door.

FOR MORE INFORMATION ON FUTURE ISSUES AND SUBSCRIPTION OFFERS, VISIT:

NEWSCIENTIST.COM/ESSENTIALGUIDE

Male infertility X chromosome mutations linked to low sperm count **p10**

Winds of change How hurricanes make way for ecological shifts **p14**

Good vibrations Alternative computer components could save energy **p16**

Whale recovery Fin whales are bouncing back in the Antarctic **p18**

Mind reading AI uses your brainwaves to see around corners **p19**

SHI TANG/GETTY IMAGES

A crowd at Wimbledon in London on 29 June

Coronavirus

Omicron still on the rise

The BA.4 and BA.5 subvariants of omicron are driving an increase in covid-19 cases in many countries, reports **Clare Wilson**

ONE in 25 people in England, or nearly 4 per cent of the country's population, were infected by the coronavirus in the week ending 29 June, according to the latest figures from the UK's Office for National Statistics (ONS). The equivalent figures for the rest of the UK were 1 in 17 people in Scotland, 1 in 20 people in Wales and 1 in 19 people in Northern Ireland, with a total of around 2.7 million infections across the UK that week. The proportion of infections has roughly doubled across the UK since the start of June.

The infections are mainly caused by a growing wave of the BA.4 and BA.5 subvariants of omicron, which were first detected in South Africa in January. These subvariants have now spread around the world and are triggering surges of cases in Australia and many European countries, such as Portugal, Germany and France. They have also become the most common subvariants in the US. This follows previous waves from the BA.1 and BA.2 subvariants of omicron in almost all countries earlier this year, making this the third omicron surge within six months.

Although similar genetically, BA.4 and BA.5 are more transmissible than BA.1 and BA.2, which were more easily passed on than the previous coronavirus variants, such as delta and alpha.

BA.1 and BA.2 have been causing milder illness than previous forms of covid-19, both because of intrinsic features of the viruses and the fact that many people had partial immunity to covid-19 from vaccines and past infections.

Some research in hamsters has suggested that BA.4 and BA.5 are deadlier than BA.2. But a recent study from South Africa suggests the two latest omicron subvariants are similar in illness severity to the first ones, based on the number of people admitted to hospital during the waves. "We are seeing no increase in disease severity," says Mary-Ann Davies at the University of Cape Town in South Africa.

> **"The fact that BA.4 and BA.5 are more transmissible is causing issues for health services"**

But it is difficult to compare across countries because of differences in populations, vaccination rates and which coronavirus variants have dominated, she says. For instance, South Africa has a relatively young population and older people tend to experience more severe covid-19. "We are looking at an interplay between the virus and the range of immune responses that the population have," says Davies.

Other open questions include whether catching BA.4 or BA.5 following a previous covid-19 infection could lead to worse health than just having it once, and the prospects of developing long covid from the new subvariants. A recent study suggested that the risk of long covid from BA.1 and BA.2 is half that of delta, but there hasn't yet been time to learn how BA.4 and BA.5 compare.

Even if the latest omicron surge is similar in illness severity to the first, the fact that BA.4 and BA.5 are more transmissible is still causing issues for health services. In the UK, rising infections are seeing more people admitted to hospital with covid-19, adding to existing issues.

By the end of June, the number of people in UK hospitals with covid-19 had climbed back to levels last seen in April this year. According to the ONS, as of 5 July, 64 per cent of people in English hospitals had an "incidental" covid-19 infection – in other words, it was detected by a screening test and wasn't their primary reason for being in hospital. But such infections can still worsen people's illness and cause difficulties for hospitals, says Tom Lawton, an intensive care doctor in Bradford, UK. "It's extra pressure on a system that really doesn't need it right now." ■

Astronomy

Seeing further than ever before

This stunning full-colour image from the James Webb Space Telescope is just a taste of what is to come, says **Leah Crane**

THE first deep-field image from NASA's James Webb Space Telescope (JWST) has revealed galaxies we have never seen before. Released on 11 July, it is zoomed in further than any previous infrared picture we have taken of the cosmos. But the record won't stand for long, as the telescope continues to push the limits of astronomical observation. As *New Scientist* went to press, four more images were scheduled to be released.

> "Being able to see so deeply into the universe will help astronomers understand the earliest stars"

JWST launched from French Guiana at the end of 2021 and arrived in its final orbit around the sun in early 2022. Images with high enough quality to use for science have now started to beam down to Earth. US president Joe Biden announced the first of these in a press conference at the White House on 11 July.

The image, right, shows a region of space called SMACS 0723, which contains what astronomers call a gravitational lens. In areas like this, a massive object relatively close to Earth behaves like a magnifying glass, distorting space and stretching the light of anything behind it. The gravitational lens in SMACS 0723 is particularly strong because the nearby object distorting space-time isn't one galaxy, but a large cluster of galaxies.

The small specks and streaks of light amplified by the lens and visible around the edges of the image are distant, incredibly faint galaxies – some of the first that ever formed.

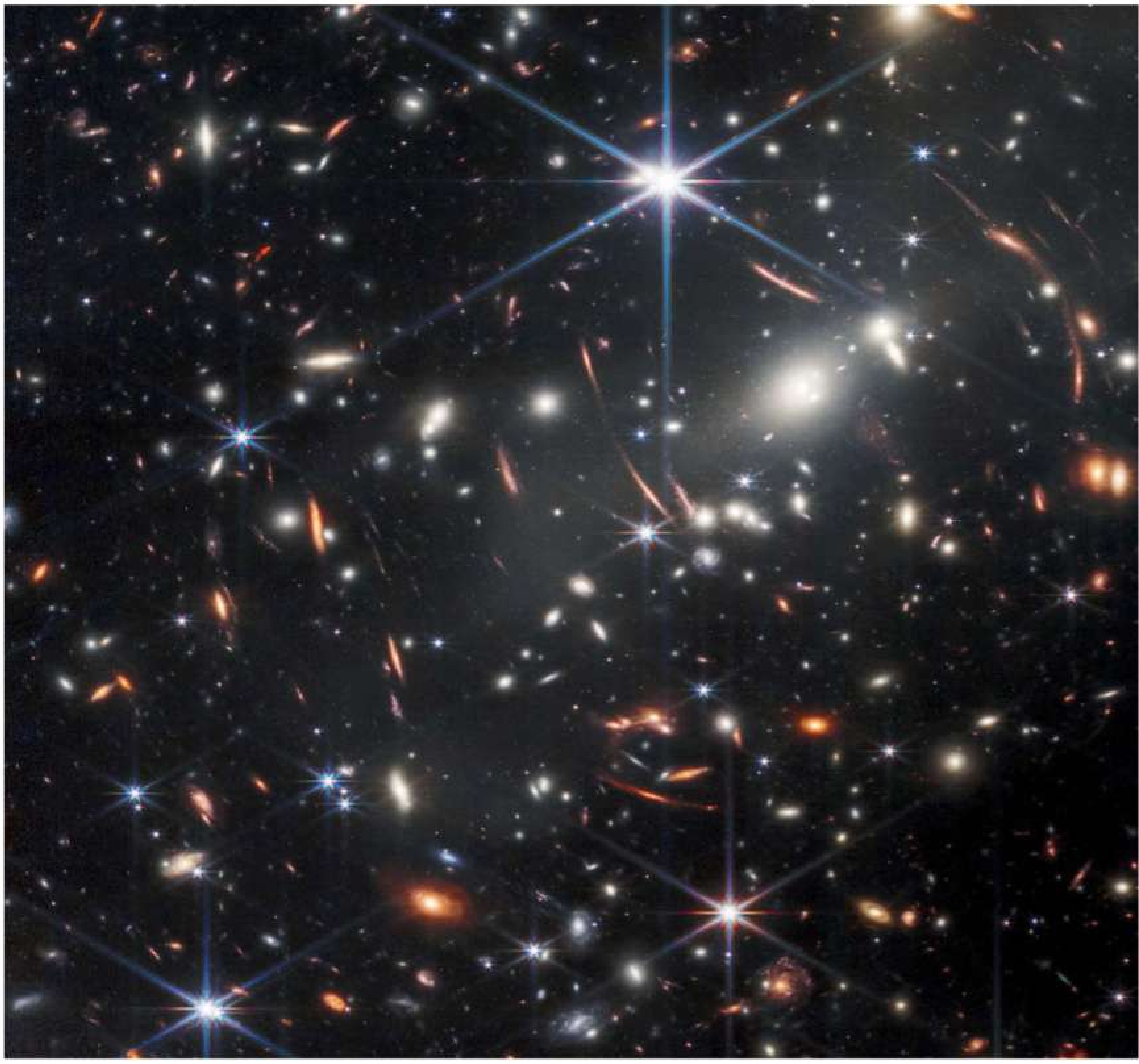
We couldn't see these galaxies before now. That is partly because of the expansion of the universe: the further away an object is, the faster it is moving away from us and the redder its light appears because of that motion. JWST can spot these because it uses infrared light, allowing it to see objects that appear so red that they have become invisible to its predecessor, the Hubble Space Telescope, which observes light mainly in visible wavelengths.

Being able to see so deeply into the universe – and thus far back in time – will help astronomers understand the earliest stars.

"We think that when stars form from primordial material in the distant universe, they form in a very different way, but we've never really observed that before," says Stephen Wilkins at the University of Sussex in the UK. "There's a lot of crucial physics there that we don't know anything about."

Understanding the formation of these early stars and galaxies could also help solve the mystery of how the seeds of supermassive black holes form.

This first image is a tantalising



NASA, ESA, CSA, AND STSCI

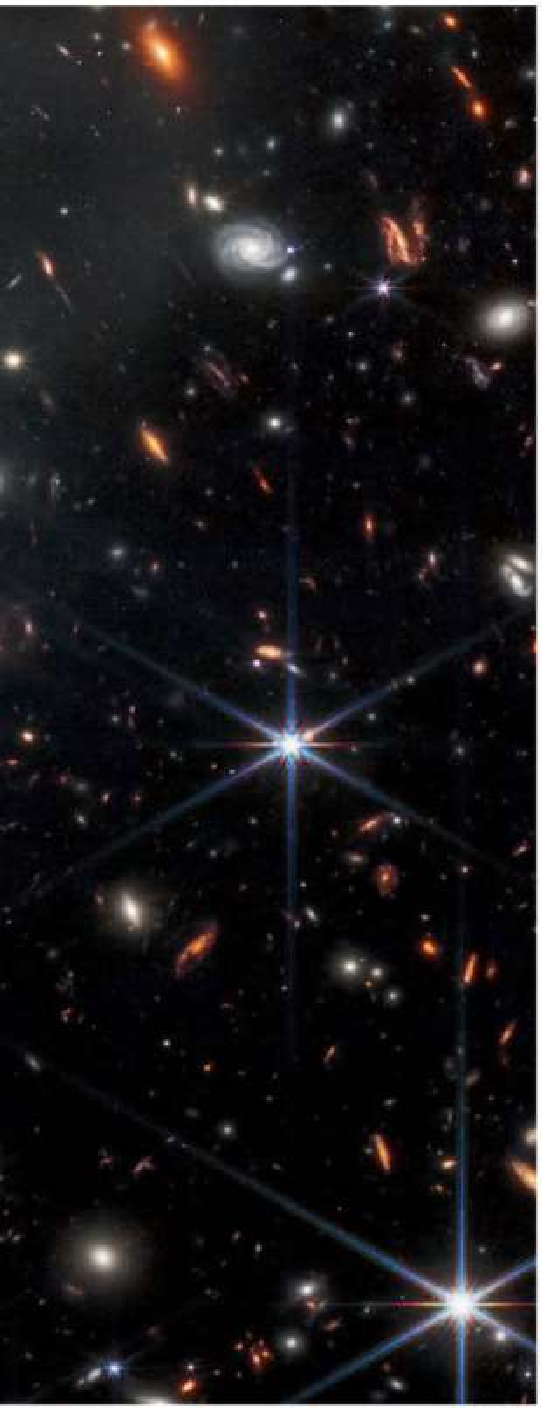
A region of space called SMACS 0723 that contains a light-warping gravitational lens

1.5m

Distance JWST is from Earth, in kilometres

2021

Year JWST launched from French Guiana



hint of what is to come from JWST, in the form of both more pictures and detailed observations of the universe. In the coming weeks and months, the floodgates of JWST science are set to open and transform our understanding of the cosmos.

"All the data we've seen before now has just shown that it's actually working – but [this] is the first data that we can potentially do science on, and very soon we'll get data that we can definitely do science on," says Wilkins. ▮

Technology

How JWST's striking first colour image was made

Will Gater

ON MONDAY, US president Joe Biden unveiled "Webb's First Deep Field", the first full-colour image released by the James Webb Space Telescope (JWST) team (see main story, left).

For Joseph DePasquale, the lead JWST image processor at the Space Telescope Science Institute in Baltimore, Maryland, the release was a moment of "relief" and "gratitude" after months of what he describes as, at times, an emotional task.

He recalls working on one of the first images downloaded from the telescope – four more of these were due to be released as *New Scientist* went to press. "I got really deep into the details. Then, at one point, I took a step back and I pulled myself out of the pixel level and looked at the image as a whole. It was a very overwhelming, kind of moving, experience," he says.

> "When you first open the raw image, it essentially just looks like a blank screen, just black"

"[I was] literally sitting at my desk looking at the very first real-colour image from Webb knowing that I'm the first person in the world to ever have seen this. That moment for me was just amazing."

The pictures DePasquale and his colleague, Alyssa Pagan, have been processing were beamed back across the 1.5 million kilometres of space between Earth and the telescope as a stream of 1s and 0s.

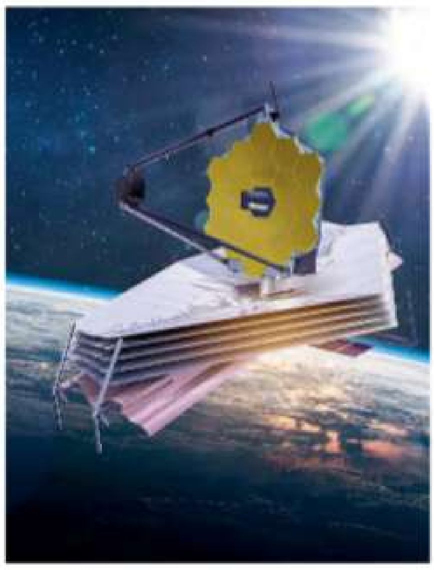
This binary information was then formed into an image file at the Space Telescope Science Institute, the project's US base. But these raw images look very different from the one we saw this week.

For starters, the raw data has an enormous dynamic range. This means that much of the detail is contained in the dark regions of the picture, says DePasquale. "When you first open that image, it essentially just looks like a blank screen, just black," he says. Image-processing software is used that brightens the picture to reveal hidden subtleties within.

The resulting scenes are black and white, however, as the detectors in JWST's instruments only create monochromatic data. To make colour views, the team had to map different filtered wavelengths of infrared light, captured in monochrome by the telescope, onto three colours – red, green and blue. By combining the resulting three images, whose bright and dark areas now represent the contribution of each of those assigned hues, a final full-colour picture takes shape.

The shades that emerge from this mix really depend on which of the telescope's instruments is being used, says DePasquale. "NIRCam [JWST's primary imager] has produced images that have more earthy brown and deep-blue hues in them, depending on the object. MIRI [a second imager on JWST], seeing in mid-infrared, sees the sky very differently and produces some very interesting colours leaning more towards blues and purples," he says.

JWST's golden mirror is made up of 18 hexagonal segments



SHUTTERSTOCK/DIMA ZEL

Six points

One striking aspect of the new JWST imagery are six-pointed stars bisected by a thin line (see image left). "That's very unique to Webb and I think at some point that's going to become an iconic indicator [of a JWST image]," says DePasquale. The spiky motif is what's known as a diffraction pattern and it is something that arises from a characteristic of the telescope called the point spread function.

This point spread function reflects the way in which the JWST optical system "imprints" itself on the light that it captures of a point source, such as a bright star, explains DePasquale. "It's very highly dependent on the construction of the observatory," he says. Hubble's internal optics, for example, bent and interacted with light from point sources in such a way as to produce images of stars that had four lines sticking out of them.

"Webb, because it has hexagonal mirrors, imprints a completely different-looking point spread function," says DePasquale.

Aside from the telescope's optical idiosyncrasies, DePasquale says it is the sharpness of the pictures that really makes JWST's images special. "Webb, with its precision and its resolution, is able to bring out a level of detail that we have never been able to see in the infrared universe." ▮

Research funding

UK scientists face uncertain future

Politicians have promised to replace a funding stream from the European Union, but Boris Johnson's departure has cast doubt on these plans, reports **Jonathan O'Callaghan**

THE UK government is still preparing to leave the European Union's €100 billion Horizon research programme, the largest collaboration of scientists in the world, after Boris Johnson's resignation as prime minister last week.

The UK's participation in Horizon has been in doubt since it voted to leave the EU in 2016. Under the terms of the Brexit withdrawal agreement in 2020, it could still be included as an "associate member" like other nations, such as Norway and Israel, but the European Commission is withholding access amid a row on border checks between Great Britain and Northern Ireland.

At the end of June, the European Research Council (ERC) cancelled more than 140 UK-led grants awarded in its latest funding round as a result of the dispute. George Freeman, then the UK science minister, accused the EU of "weaponising science" in an interview with *New Scientist* on 24 June. Freeman said he was planning to launch a new research programme, currently known as "Plan B", in September if the UK wasn't allowed to rejoin Horizon.

JAMES VEYSEY/SHUTTERSTOCK

Boris Johnson announced his resignation at 10 Downing Street on 7 July

However, Freeman was one of a slew of ministers who resigned last week to call for Johnson to step down, and a new science minister hasn't yet been appointed.

Details on the Plan B proposal are supposed to be published on 21 July before MPs go on recess for the summer. A spokesperson for the UK government told *New Scientist* that the government's position hasn't changed, and the publication of Plan B will still be going ahead, meaning the UK would be set to formally leave Horizon at the end of 2022 when its membership ends.

However, Johnson's resignation leaves open the possibility that the UK's stance on Northern Ireland could change and it might rejoin Horizon. "What's happening now is anyone's guess really," says James Wilsdon at the University of Sheffield, UK. "If the Conservative party chooses a less Brexity flavour of leader, there's a possibility of a more flexible approach to the economic trade debate in Northern Ireland and reopening the question of Horizon."

The ERC declined to comment on the planned change of leadership in the UK, but its president, Maria Leptin, says she hopes the situation can be resolved. "I very much regret that we are currently unable to sign new grants with UK-based applicants," she says. "Ultimately, we are bound by the legal rules. I sincerely hope that our political leaders will find a path that will allow us to continue supporting talented researchers based in the UK."

The majority of funding for scientific research in the UK still comes from UK institutions, such as UK Research and Innovation. But the loss of prestige from no longer being able to compete for ERC grants and the diminished opportunities for collaboration with scientists across the EU and beyond are major causes of concern for UK-based scientists.

There are also worries that a new prime minister could decide to cut back on research spending. The UK government had pledged about £15 billion to Horizon over the next seven years, and that funding has been earmarked to be redirected into Plan B.

"If you're looking to make cuts, then, in terms of research funding, Plan B is the easiest place to start," says Wilsdon. "In terms of the big politics, it's not likely to cause that much pain if you've got an incoming leadership that's less committed to science." ▮

Fertility

Male infertility linked to mutations on X chromosome

AN INTERNATIONAL study has identified more than 50 genes on the X chromosome in which mutations may cause poor sperm production.

Nearly half of all men with low or zero sperm count have no medical explanation for their infertility. Previous studies have identified three X chromosome genes that could be involved in sperm production issues, but Csilla Krausz at the University of Florence in Italy wondered if there might be others.

Krausz and her colleagues ran genetic analyses on 2354 men from across Europe with less than 10,000 sperm per millilitre of their semen, whose doctors had found no causes for the low or absent sperm counts. They compared the results with those from another 209 men with normal sperm counts of up to 200 million per millilitre. The study didn't include transgender or non-binary people.

The analysis discovered hundreds of mutated genes on the infertile men's X chromosomes, including the three identified in earlier studies. Through further investigation, the researchers honed in on 21 new genes that they considered particularly strong culprits for poor sperm production.

Most of the mutations in these genes affected the way the men's testicular cells divide to make sperm cells, and the researchers found them repeatedly in these men – as well as in some infertile male flies and mice.

"Most of the mutations affected the way the men's testicular cells divide to make sperm cells"

The team also determined another 34 X chromosome genes in which mutations were probably involved in male infertility and should be investigated further (*American Journal of Human Genetics*, doi.org/h4p7).

"People often think about the X chromosome as a female chromosome, because females have two X chromosomes," says Krausz. "But [our findings] are fitting with the theory that the X chromosome is important for male reproduction." ▮

Christa Lesté-Lasserre

Sign up for free

THE KNOWLEDGE

NEWS MADE MANAGEABLE

Your five minute daily newsletter

Analysis **Military technology**

Attempts to regulate autonomous weapons are failing

An upcoming United Nations meeting will most likely struggle to reach a consensus on controlling the use of "killer robots", says **David Hambling**

INTERNATIONAL attempts to regulate the use of autonomous weapons, sometimes called "killer robots", are faltering and may be derailed if such weapons are used in Ukraine and seen to be effective.

DIMITAR DILKOFF/AFP VIA GETTY IMAGES

A Ukrainian soldier observes the area near a destroyed bridge

No country is known to have used autonomous weapons yet. Their potential use is controversial because they would select and attack targets without human oversight. Arms control groups are campaigning for the creation of binding international agreements to cover their use, like the ones we have for chemical and biological weapons, before they are deployed. Progress is being stymied by world events, however.

A United Nations' Group of Governmental Experts is holding its final meeting on autonomous weapons from 25 to 29 July. The group has been looking at the issue since 2017, and according to insiders, there is still no agreement. Russia opposes international legal controls and is now boycotting the discussions, for reasons relating to its invasion of Ukraine, making unanimous agreement impossible.

"The United Nations process operates under a consensus mechanism, so there is no chance for a blanket ban on autonomous weapons," says Gregory Allen at the Center for Strategic and International Studies in Washington DC. Yet there could still be a way for progress, he says, through the widespread adoption of a code of conduct.

Such a code could be based on Directive 3000.09, the first national policy on autonomous weapons, which was introduced in the US in 2012. This is being revisited under a Pentagon requirement to revise rules every 10 years.

Allen says Directive 3000.09 is widely misunderstood as outlawing autonomous weapons in the US. It actually sets out criteria such weapons have to meet and a demanding approval process, with the aim of minimising risk to friendly forces or civilians. There are exceptions, such as anti-missile systems and landmines. Allen says the rules are so exacting – requiring sign-off from the US military's highest-ranking officer, for example – that no system has yet been submitted for review.

If Russia uses autonomous weapons in Ukraine, attitudes may change. Russia has KUB loitering munitions that can be used in autonomous mode. These have the ability to wait in a specified area and attack when a target is detected by the device. Allen doubts they have been used autonomously, but says Russia sent similar Lancet loitering munitions to its troops in Ukraine in June. These have the ability to find and attack targets without oversight. There are no reports that either have been used in autonomous mode.

The Switchblade 300 miniature aerial missile system

MORADIAN/US MARINE CORPS/ALAMY LIVE NEWS

"I can guarantee, if Russia deploys these weapons, some people in the US government will ask 'do we now, or will we later, need comparable capabilities for effective deterrence?'," says Allen.

Mark Gubrud at the University of North Carolina at Chapel Hill also says that any reports of autonomous weapons being used in Ukraine will increase Western enthusiasm for such weapons or resistance to calls for arms control.

Allen says Lancet munitions are unlikely to meet the criteria of Directive 3000.09, which requires less than 1 in a million errors. This is easier for anti-aircraft missiles to achieve than for weapons like Lancet, which need to distinguish military trucks from many other vehicles like school buses.

Forthcoming weapons might meet the criteria. Drone-maker AeroVironment has demonstrated an automatic target-recognition system it says can identify 32 types of tank. This could be used to convert its operator-controlled Switchblade loitering munitions to autonomous. Switchblades are currently being supplied to Ukraine, and could be used to hit Russian artillery positions from long range. AeroVironment acknowledges that fielding such a weapon autonomously raises ethical issues.

Allen says the extensive use in Ukraine of radio-frequency jamming, which breaks contact between human operators and drones, will increase the interest in autonomous weapons, which don't need a link to be maintained.

Gubrud doubts whether Michael Horowitz, the director of the Pentagon's Emerging Capabilities Policy Office, who is leading the review of Directive 3000.09, will call for stricter rules.

> **"If Russia deploys these weapons, people in the US will ask 'do we need comparable capabilities?'"**

Allen also says the review of the directive probably won't change much, but may add details on issues like machine learning and when advances require a system to be reassessed.

The US Department of Defense didn't respond to a request for comment before publication.

In the absence of binding international laws or codes of conduct, autonomous weapons will continue to develop. Conflicts such as the one in Ukraine will drive demand for new and better weapons, and it may be only a matter of time before killer robots advance onto the battlefield. ▮

LOOKING TO
**STAY IN TUNE
WITH INFLATION?**

SCAN ME

**JUPITER STRATEGIC
ABSOLUTE RETURN BOND FUND**

Inflation is soaring, and central banks are starting to raise interest rates in response, creating a potentially discordant environment for bond investors. At Jupiter we have investment capabilities that address these issues in a single strategy, potentially helping to restore harmony. We call this human advantage 'the value of active minds'. To discover more reasons to consider an allocation now, visit **jupiteram.com/SARB**

As with all investing, your capital is at risk. **Investment risk** – while the Fund aims to deliver above zero performance irrespective of market conditions, there can be no guarantee this aim will be achieved. The actual volatility of the Fund may be above or below the expected range, and may also exceed its maximum expected volatility.

JUPITER
ASSET MANAGEMENT

This advert is for informational purposes only and is not investment advice. **We recommend you discuss any investment decisions with a financial adviser, particularly if you are unsure whether an investment is suitable.** The Key Investor Information Document and Prospectus are available from Jupiter on request. The fund is a sub-fund of Jupiter Asset Management Series plc, a UCITS umbrella fund incorporated in Ireland. Issued by Jupiter Asset Management (Europe) Limited which is registered in Ireland and authorised and regulated by the Central Bank of Ireland. JAM000228-001-0522

Artificial intelligence

Nonsense videos teach AI physics

Algorithms that understand how objects obey physical laws could be more efficient

Matthew Sparkes

TEACHING artificial intelligence to understand simple physics concepts, such as that one solid object can't occupy the same space as another, could lead to more capable software that takes less computational resources to train, say researchers at DeepMind.

The UK-based company has previously created AI that can beat expert players at chess or write software, but these models are specialised and lack a general understanding of the world. As DeepMind's researchers say in their latest paper, "something fundamental is still missing".

Now, Luis Piloto at DeepMind and his colleagues have created an AI called Physics Learning through Auto-encoding and Tracking Objects (PLATO) that is designed to understand that the physical world is composed of objects that follow basic physical laws.

The researchers trained PLATO to identify objects and their interactions by using simulated videos of objects moving as we would expect, such as balls falling to the ground, rolling behind each other and bouncing off each other. They also gave PLATO data showing which pixels in every frame belonged to each object.

"An object-centric view of the world could give an AI a more generalised and adaptable set of abilities"

To test PLATO's ability to understand five physical concepts, such as solidity, persistence (that an object doesn't tend to vanish) and unchangingness (that an object tends to retain features like shape and colour), the researchers used another series of simulated videos. Some showed objects obeying the laws of physics, while others depicted nonsensical actions, such as a ball rolling behind a pillar, not emerging from the other side, but then reappearing from behind another pillar further along its route.

They tasked PLATO to predict what would happen next in each video, and found that its predictions were reliably wrong for nonsensical videos, but usually correct for logical ones, suggesting the AI has an intuitive knowledge of physics (*Nature Human Behaviour*, doi.org/h4qp).

Piloto says the results show that an object-centric view of the world could give an AI a more generalised and adaptable set of abilities. "If you consider, for instance, all the different scenes that an apple might be in," he says. "You don't have to learn about an apple on a tree, versus an apple in your kitchen, versus an apple in the garbage. When you kind of isolate the apple as its own thing, you're in a better position to generalise how it behaves in new systems, in new contexts. It provides learning efficiency."

Mark Nixon at the University of Southampton, UK, expressed concerns about the reproducibility of the results, because the paper says that "our implementation of PLATO is not externally viable".

"That means they're using an architecture that other people probably can't use," he says. "In science, it's good to be reproducible so that other people can get the same results and then take them further."

Chen Feng at New York University says the findings could help to lower the computational requirements for training and running AI models.

"This is somewhat like teaching a kid what a car is by first teaching them what wheels and seats are," he says. "The benefit of using object-centric representation, instead of raw visual inputs, makes AI learn intuitive physical concepts with better data efficiency." ▮

Botany

Hurricane in Jamaica helped change mountain ecology

THE destruction caused when tropical storms sweep across cool, high-elevation areas may open up enough ecological space for warm-adapted plant species to establish themselves, speeding up the ecological shifts caused by climate change.

Edmund Tanner at the University of Cambridge began tracking vegetation plots that are about 1580 metres above sea level in the Blue mountains of eastern Jamaica in the mid-1970s, suspecting that a hurricane might come through his study area at some point during his academic career. Hurricane Gilbert struck Jamaica in 1988.

The storm damaged the plots Tanner had been observing every few years since 1974. He and his colleagues, with support from local organisations including the Jamaica Conservation and Development Trust, tracked the ongoing changes every 10 years following the damage, with the most recent survey occurring in 2014.

The researchers found that the mortality rate for trees peaked between 1984 and 1994, as did the rate of appearance of new trees in the plots. Both rates were about 66 per cent higher than in earlier and later decades.

The researchers also counted the number of trees belonging to each species in the plots and used already published data on the altitude preference of each species to work out a "mean community altitude score" for the plots. They found that this score decreased by almost 60 metres over the 40 years of the study. This means the plots contained fewer trees with a preference for higher altitudes and more trees that favoured lower altitudes in 2014 than in 1974.

NOAA CLASS

Hurricane Gilbert, which struck Jamaica in September 1988

What's more, beginning in the decade 1984 to 1994, the trees that established themselves in the plots had a mean altitude score significantly lower than expected by chance, meaning they included a high number of trees with a lower altitude preference (*Ecography*, doi.org/gp8jdz).

"Higher altitude species are dying preferentially," says Tanner. "It turned out that the effects [of the hurricane] lasted for decades." ▮

Joshua Rapp Learn

Health

Men may eat more in summer as the sun makes them hungry

Clare Wilson

WINTER may be seen as the time to fill up with food, but in fact, sunny summer months are when men eat more calories – unlike women.

The effect seems to occur because sunlight makes the skin release an appetite-stimulating hormone, says Carmit Levy at Tel Aviv University in Israel.

Levy and her colleagues noticed the effect in experiments in mice, in which male animals exposed to UV light ate more food.

To see if humans do the same, the team used data on about 3000 people who had filled in questionnaires as part of the Israeli government's national health and nutrition survey. Between March and September, the men consumed about 17 per cent more calories per day than they did during the rest of the year, while the women's food intake stayed about the same.

Human appetite is influenced by many complex systems, but a substance called ghrelin seems to be the only hormone that directly stimulates eating. It was thought to be mainly secreted by the stomach when empty. "It tells the brain to eat more," says Caroline Gorvin at the University of Birmingham, UK.

Further investigation revealed that exposing male mice to UVB radiation, which is present in sunlight, raised levels of ghrelin secretion by fat cells in their skin. This was blocked by the female sex hormone oestrogen, which may explain why the effect wasn't seen in the female mice or the women.

Boosted ghrelin secretion was also seen in men's skin samples that were exposed to UV light in the lab (*Nature Metabolism*, doi.org/h4st).

Skin hasn't previously been thought to play a role in appetite, says Gorvin. The reason for the effect is unclear, but it may be an adaptive response to fuel greater physical activity in summer, says Levy. ▮

Space

The chance falling rockets will hit someone is increasing

Jonathan O'Callaghan

TPG/GETTY IMAGES

Parts of a rocket that fell in Guizhou, China, in 2014

PIECES of rocket falling uncontrolled back into our atmosphere may cause casualties, unless action is taken to limit the risk they pose.

The number of rockets launched annually has been steadily increasing, with 135 successfully going up in 2021, a record for a single year. Many launches involve discarding part of the rocket after it boosts any satellites it is carrying into a desired orbit. The rocket parts often then fall back to Earth, and more than 1000 rocket bodies are estimated to have uncontrollably re-entered the atmosphere in the past 30 years.

Much of this debris falls in the ocean, which covers more than two-thirds of Earth's surface, but some hits things on land.

In May 2020, a 12-metre-long pipe suspected to originate from a Chinese rocket fell in a village in the Ivory Coast. In April 2022, another piece of debris reported to come from a Chinese rocket landed near a village in India. Wreckage of a Chinese Long March rocket also landed in Guizhou, China, in December 2014 (see picture).

Now, Michael Byers at the University of British Columbia in Canada and his colleagues have calculated the danger that such falling debris poses. They say there is a 10 per cent chance of one or more casualties being caused by falling debris over the next decade, and the risk is disproportionately higher in low-income nations near the equator, where population densities are higher and more debris tends to fall because more rocket bodies travel over the equator (*Nature Astronomy*, doi.org/gqg6pz).

"I have no doubt there will be a serious incident: hurting somebody or damage to property"

"We think this has to stop," says Byers, who wants rocket companies to be told to keep leftover fuel to target safe re-entries over uninhabited ocean regions. "We have modern rockets that can avoid uncontrolled re-entries, rather than playing Russian roulette with the Ivory Coast and India. Who's to say the next piece won't come down in central Mumbai?"

Jonathan McDowell at the Harvard-Smithsonian Center for Astrophysics says rocket stages discarded in orbit are a large problem. "When you have stages left in orbit, there's a collision risk," he says. Such stages can also explode because of fuel left on board. "The only way to make sure your rocket isn't going to blow up is to de-orbit it," says McDowell.

If rocket debris does cause damage or casualties on Earth, Ram Jakhu at McGill University in Montreal, Canada, says legal action can be taken under the United Nations's Liability Convention of 1972. Only one such case has been seen before, when Canada was awarded CAN$3 million (US$2.3 million) from the Soviet Union in 1981 after a Soviet satellite crashed in the country in 1978, but the convention could be used again.

"I have no doubt there is going to be another serious incident," says Jakhu. "There's a strong probability of hurting somebody or damage to property."

Some organisations, like SpaceX, can now land the lower part or first stage of their rockets following a launch. Yet second stages – used to boost satellites into their final orbits – are still regularly left to drift in space, often because they carry the precise amount of fuel to do their job rather than leaving some for a controlled return.

SpaceX and the China National Space Administration didn't respond to a request for comment.

"The goal is to have international agreement to phase out uncontrolled re-entries," says Byers. "Some older rocket designs may need to be put out of service or modified." ▮

Technology

Computer components based on vibrations could save energy

Karmela Padavic-Callaghan

A COMPUTER component that uses vibrations rather than electrons could approach the physical lower limit for energy use when processing and sending information.

The minimum amount of energy needed for a computer to perform a computational step is called the Landauer limit, named after the physicist Rolf Landauer. In his calculations, Landauer didn't consider any specific computer design, but rather the basic energy cost required to manipulate information.

Conventional computers, which are made of semiconductors, work by controlling the flow of electrons within different circuits to perform operations. Stopping thermal fluctuations from affecting the electrons' movements and causing errors incurs extra energy costs. Consequently, the energy consumption of the computers we use in our homes is about 10,000 times larger than the Landauer limit.

Nanomechanical computers that use tiny vibrations instead of electrons, however, wouldn't have this additional energy cost.

Warwick Bowen at the University of Queensland in Australia and his colleagues have now created a nanomechanical logic gate – a basic building block needed for such a computer – that doesn't require electric wires.

The new gate contains a membrane 1000 times thinner than a human hair. Bowen says it is like a "nanoscopic trampoline" that can vibrate with a low or a high amplitude. The two amplitudes correspond to 0 and 1 values in an electronic computer, so basic computations can be done by amplifying or dampening them.

Information is input into the gate by a sound wave, a travelling vibration. The gate's output, which is just a very simple computation, can then be fed into another gate of the same design by a sound wave as well. Sound propagating between chips plays the role of electrons moving through wires in a conventional computer (arXiv, doi.org/h4hv).

"Nanomechanical computers may prove uniquely suited for use on satellites"

"Anything you can do with an electronic, semiconductor computer, you could do with these [nanomechanical] computers," says Bowen.

At the same time, he says that the new logic gate doesn't yet operate at the Landauer limit, and he and his team are relying on theoretical calculations that show the gate must be about 1000 times smaller to actually get to that point. They are also working on ironing out all the practical details of connecting many gates together.

Raj Mohanty at Boston University in Massachusetts, whose team created some of the first nanomechanical gates more than 15 years ago, says it is now also possible to mass produce such gates on silicon chips in commercial facilities.

Nanomechanical computers are unlikely to replace the machines in our homes, but they may prove uniquely suited for use in satellites, says Bowen. A nanomechanical computer free of wires and electronics could withstand extreme conditions like solar flares, stopping it from losing information in such an event, he says.

Artificial intelligence

AI creates 3D scenes in the style of famous artworks

GETTING immersed in a 3D-version of your favourite painting could be made possible thanks to an artificial intelligence that can transfer artistic styles onto 3D scenes.

AI has been used before to transfer an artistic style onto images that can be viewed from 360 degrees, but the latest project is better at showing the small details when digitally painting scenes in different styles.

Kai Zhang at Cornell University in Ithaca, New York, and his colleagues demonstrated their style transfer system with 3D scenes involving objects such as bulldozers and dinosaur skeletons, stylised using artworks such as Vincent van Gogh's *The Starry Night* and Georges Seurat's *Sunday at Port-en-Bessin*.

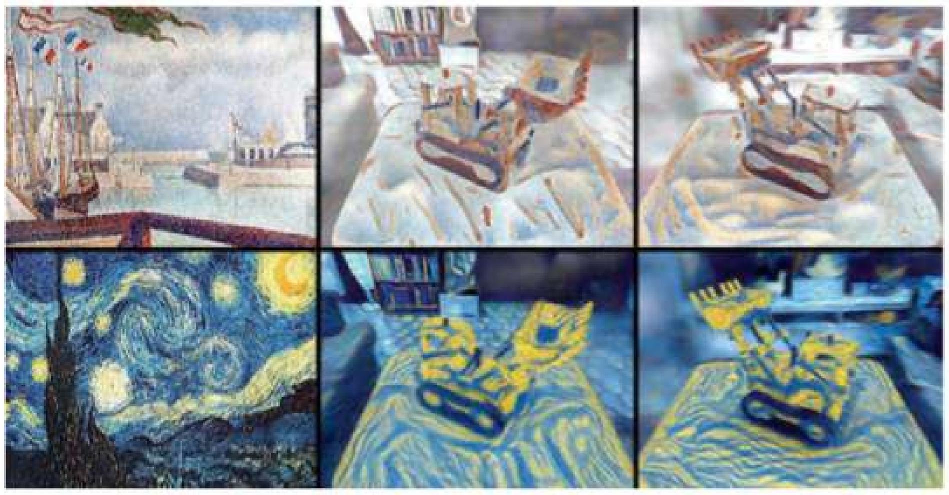
The quality improvement came from the AI having the capability to directly compare details between the original image and the newly stylised 3D scenes. For comparison, an older AI technique loses many of those original details by converting image features into a more compact statistical set for analysis.

"We are trying to really capture the subtle, artistic style, like the strokes of *The Starry Night* painting," says Zhang. "This is really important for human perception, because our human eyes are very sensitive to local details."

The team presented people they recruited online with videos of five different art styles for five different 3D scenes using both the new and older AI techniques. Each of the style transfer comparisons received 12 ratings, on average, with people favouring the new AI technique more than 86 per cent of the time compared with the most competitive older AI technique (arXiv, doi.org/h4h7).

Running the algorithm is a slow process and can take up to 20 minutes. But if it can be sped up, the method could find uses in the animated film and game industry, where visual effects artists could use a style transfer as a starting template before making additional changes by hand.

Jeremy Hsu



CORNELL UNIVERSITY AND ADOBE RESEARCH

Paintings by Seurat (top left) and van Gogh (bottom left) applied to 3D images of a bulldozer

SPECIAL LAUNCH OFFER

Smart news and analysis you can trust

i DIGITAL SUBSCRIPTION

Discover more than just the headlines.

To find out more, visit

www.inews.co.uk/new-scientist

Enjoy full access to i digital from just ~~£1.63~~ £0.76 per week*

By subscribing to i you will:

- Get full access to inews.co.uk
- Unlock the i news app + PDF of newspaper
- Support our journalism
- Enjoy 70% fewer adverts
- Access to exclusive newsletter from i columnists
- Gain access to all i puzzles

*T&Cs: available to registered users only. Register for free at inews.co.uk. Offer ends 31.12.22.

Wildlife

Fin whales bounce back

Groups of up to 150 whales have been seen in the Antarctic

Jason Arunn Murugesu

LARGE groups of southern fin whales (*Balaenoptera physalus quoyi*) have been seen in the Antarctic for the first time since the hunting of this species in the southern hemisphere was prohibited in 1976.

Fin whale numbers dramatically dwindled in the 20th century as they were hunted for their oil.

Helena Herr at the University of Hamburg in Germany travelled to the Weddell Sea near Antarctica in 2018 on the icebreaker Polarstern.

Using a helicopter, the researchers flew for a total of 3251 kilometres over the ocean. They counted 100 groups of fin whales consisting of up to four animals, and eight unusually large groups of up to 150 whales feeding together (*Scientific Reports*, doi.org/h4hk).

Their recovery is a good news story, "but we shouldn't forget that climate change continues to be a threat", says Herr. ▮

DAN BEECHAM

Palaeontology

Three-eyed predator stalked ancient seas

A THREE-EYED animal with wing-like fins once swam through shallow seas, using heightened visual perception to hunt smaller sea creatures.

Stanleycaris hirpex lived in the Cambrian Period about 500 million years ago, not long after the first eyes appeared in the fossil record. It is the first animal with three eyes known among the arthropods, the group containing insects, arachnids and crustaceans, but the researchers who described it think there may be others in which a third eye has been overlooked.

S. hirpex was roughly the size of a human hand and had two protruding eyes with hundreds of lenses on each side of its head, plus a third, much larger eye in the middle.

Living among finger-sized animals, it probably used its advanced visual system to chase down fast-moving prey, says Joseph Moysiuk at the University of Toronto in Canada. "It kind of jives that when we see the evolution of the first predators, we also see the evolution of these complex sensory systems where we have different eyes, maybe performing different tasks for the organism," he says.

Moysiuk and his colleagues recently investigated hundreds of exceptionally well-preserved fossils of *S. hirpex* unearthed from the Cambrian Burgess Shale in the Canadian Rockies of British Columbia (*Current Biology*, doi.org/h4h3).

Many of their 268 specimens even had their soft tissue intact, including brains, nerves and reflective materials in their visual systems. "When you split one of these rocks in the field, you can see their eyes gleaming – after 506 million years – in the sunlight. So it was pretty clear from when we first started looking at the organism that it had three eyes," says Moysiuk.

> "When you split one of these rocks in the field, you can see their eyes gleaming"

The animals had 17 body segments, two pairs of stiff blades along the lower third of its body and spiked claws that could probably rake prey right into its toothed jaws. "This was a pretty ferocious animal," he says.

Moysiuk thinks a large middle eye combined with two lateral eyes might have been the common form for early invertebrates, before evolving towards two or more paired eyes in later species. For example, the 520-million-year-old *Lyrarapax* had a similar structure on its forehead that might have been an eye. ▮

Christa Lesté-Lasserre

Environment

Pesticides and pollutants found in bats' livers

Sean Mowbray

BATS across Germany are riddled with residues of pesticides and persistent organic pollutants, according to the largest study to sample such exposure in a European bat population.

Christoph Müller at Ludwig-Maximilians University of Munich and his colleagues collected 387 dead insect-eating bats from five species: serotine bats (*Eptesicus serotinus*), greater mouse-eared bats (*Myotis myotis*), common noctules (*Nyctalus noctule*), common pipistrelles (*Pipistrellus pipistrellus*) and brown long-eared bats (*Plecotus auratus*). They tested their livers for 209 different compounds.

A greater mouse-eared bat (*Myotis myotis*)

TOP-PICS TBK/ALAMY

Of the 28 chemicals found, the most common were polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCs), legacy pollutants long banned due to their known environmental impacts, including high toxicity and the potential to interfere with hormone systems.

All of the bats sampled were exposed to both PCBs and OCs. One bat tested positive for four compounds, while another had residues from 25 compounds (*Chemosphere*, doi.org/h4hf).

Bats can be exposed to pesticides and pollutants via their food, water or contamination of their roosts. The team expected to find residues of chemicals like PCBs and OCs, but the high amounts found were surprising, says Müller. "PCBs are still by-products of industrial production, so a new spread of these chemicals is not impossible." ▮

Technology

AI can use your brainwaves to 'see' things that you cannot

Karmela Padavic-Callaghan

AN ARTIFICIAL intelligence can use your brainwaves to see around corners. The technique, called "ghost imaging", can reconstruct the basic details of objects hidden from view by analysing how the brain processes barely visible reflections on a wall.

Ghost imaging has already been used before to reveal objects hidden around corners. It normally relies on using video recordings of faint reflections cast by an object onto a nearby wall. Daniele Faccio and Gao Wang at the University of Glasgow, UK, have now replaced the video component with electroencephalography (EEG) brain scans.

In their experiment, a person wearing an EEG headset connected to a computer stands in front of a white wall and next to a wall painted grey, which obscures the view of an object and a projector. This projector is controlled by the computer and casts a series of special patterns of light onto the object.

Some of this patterned light reflects off the object and hits the white wall or diffuses through the room. Although the person can't discern the object in the reflections, a ghost-imaging machine-learning algorithm can take the EEG data from their brain and use it to build a basic 16-by-16 pixel image of the object.

The algorithm is partly guided by a feedback loop from the brain. While it is assembling the image from the reflection, it can adjust the pattern of light being cast on the object in real time to better stimulate the person's eye and generate a stronger EEG reading. This makes the task of assembling the image easier.

> "The readings used to assemble the image contain information the wearer isn't aware of"

"We could have done this with a camera [instead of EEG]," says Faccio. "But the point is that you can actually do this with the human brain, which was not obvious because the brain is very different from a camera."

The new technology, which Faccio presented at the Optica Imaging and Applied Optics Congress in Vancouver, Canada, on 11 July, is a proof-of-concept for how AI can help people carry out tasks they normally cannot.

Faccio says the human brain simply doesn't have the kind of algorithmic capability to perform the calculations the AI does in the experiment, even though all the information needed for those calculations is already stored in the brain.

Stephen Mackinck at SUNY Downstate Health Sciences University in New York City explains that the human brain doesn't use all visual information that enters the eye in order to produce the images we see. In fact, he says, the way we normally see is tailored so that the brain uses very little energy instead of processing every single stimulus. Many of the brain processes that help us see are subconscious and inaccessible to our conscious thought, he says.

Patrick Cavanagh at Glendon College in Toronto, Canada, says that, in contrast, EEG doesn't discriminate between conscious and unconscious activity in the regions of the brain that process visual images. This means that the readings used by the algorithm to assemble the image contain information that the EEG wearer isn't aware of.

Faccio says a next step may be to try to image hidden objects faster by connecting the computer with multiple people wearing EEG headsets, or to try to differentiate between activity in the visual cortex that we are conscious of and that which is subconscious. Ultimately, Faccio and Wang would like to build a wearable device that allows the wearer's brain to collaborate with an AI. ▮

JANIECBROS/GETTY IMAGES

Electroencephalogram recordings are used to track brain activity

Environment

Optimising crop genetics could double wheat yields

Adam Vaughan

WE COULD theoretically double the amount of wheat produced globally by breeding versions of the crop that are genetically optimised for different regions, according to an analysis. But crop scientists not involved in the work are sceptical.

Crop experts have previously estimated the "management gap" – or the difference between existing yields of wheat and the theoretical potential yield that could be achieved with better management of irrigation and other factors. Now, for the first time, a team has calculated the size of the "genetic yield gap" – the difference between yields today and the maximum yield if the plant's genome was perfectly adapted to absorb nutrients, water and sunlight in different climates.

WILLIAM ROBINSON/ALAMY

Australia and Kazakhstan had the highest genetic yield gap at 70 per cent, meaning they could benefit the most from an optimised wheat genome. New Zealand was the lowest at 30 per cent. The global average, weighted against wheat harvest areas, was 51 per cent, suggesting the world could one day double wheat production simply by tweaking wheat genetics and without having to grow more of the crop.

"It's a surprise that it's that big. There's been quite a long time for [genetic] optimisation, but it clearly hasn't happened in many parts of the world," says Nigel Halford at Rothamsted Research, UK, a member of the team behind the analysis.

The study comes as wheat prices have risen for four months in a row after Russia's invasion of Ukraine disrupted grain supplies and hot weather affected key producer countries including India. Halford and his colleagues are clear that closing the genetic yield gap isn't a short-term fix. But in the long run, it could help compensate for climate change, which may curb yields of wheat because wheat plants experience heat stress above 34°C.

"It's not a solution which could be implemented straight away," says Mikhail Semenov at Rothamsted, another member of the research team – but he thinks it is theoretically possible.

The team arrived at its estimates by looking at climatic data for 53 sites from 33 wheat-growing countries in conditions representative of how 91 per cent of the world's wheat is grown. The gap between yields today and the maximum from an idealised genome for that location was estimated using a computer model known as Sirius (*Nature Food*, doi.org/h4hz).

51%

Global average shortfall from wheat's full genetic potential

Optimising the genome of wheat cultivars to increase yield could be done via traditional plant breeding or in a much faster way via gene-editing technology.

Wheat prices have risen for four months in a row

But commercial wheat breeders in the UK employing cutting-edge technologies are only achieving around 1 per cent genetic yield gain each year, says Donal O'Sullivan at the University of Reading, UK, who wasn't involved in the study.

"There is always scope for the rate of gain to be increased by introducing technologies such as gene-editing that have not yet been widely deployed, but to suggest that there is a whole raft of unexploited and game-changing breeding technologies that would allow wheat yields to be doubled any time soon is fanciful," he says.

Reducing the yield management gap is currently much more feasible than the genetic yield gap estimated by the new paper, says José Luis Araus at the University of Barcelona, Spain. "I don't share their optimism of doubling yields just based on breeding." ▮

Technology

Gel-coated battery could stop phones catching fire

Matthew Sparkes

LITHIUM-ION batteries used in smartphones and other devices are susceptible to catching fire and even exploding if they begin to overheat, but a material inspired by the hydrogels found in nappies and contact lenses could reduce the risk.

The batteries used in many modern technologies each contain one or more lithium-ion cells, which can collectively generate a large amount of power. But if one or more cells become damaged, they can trigger a chain reaction that releases a battery's power dramatically and dangerously in a process called thermal runaway. This can lead to a fire or explosion.

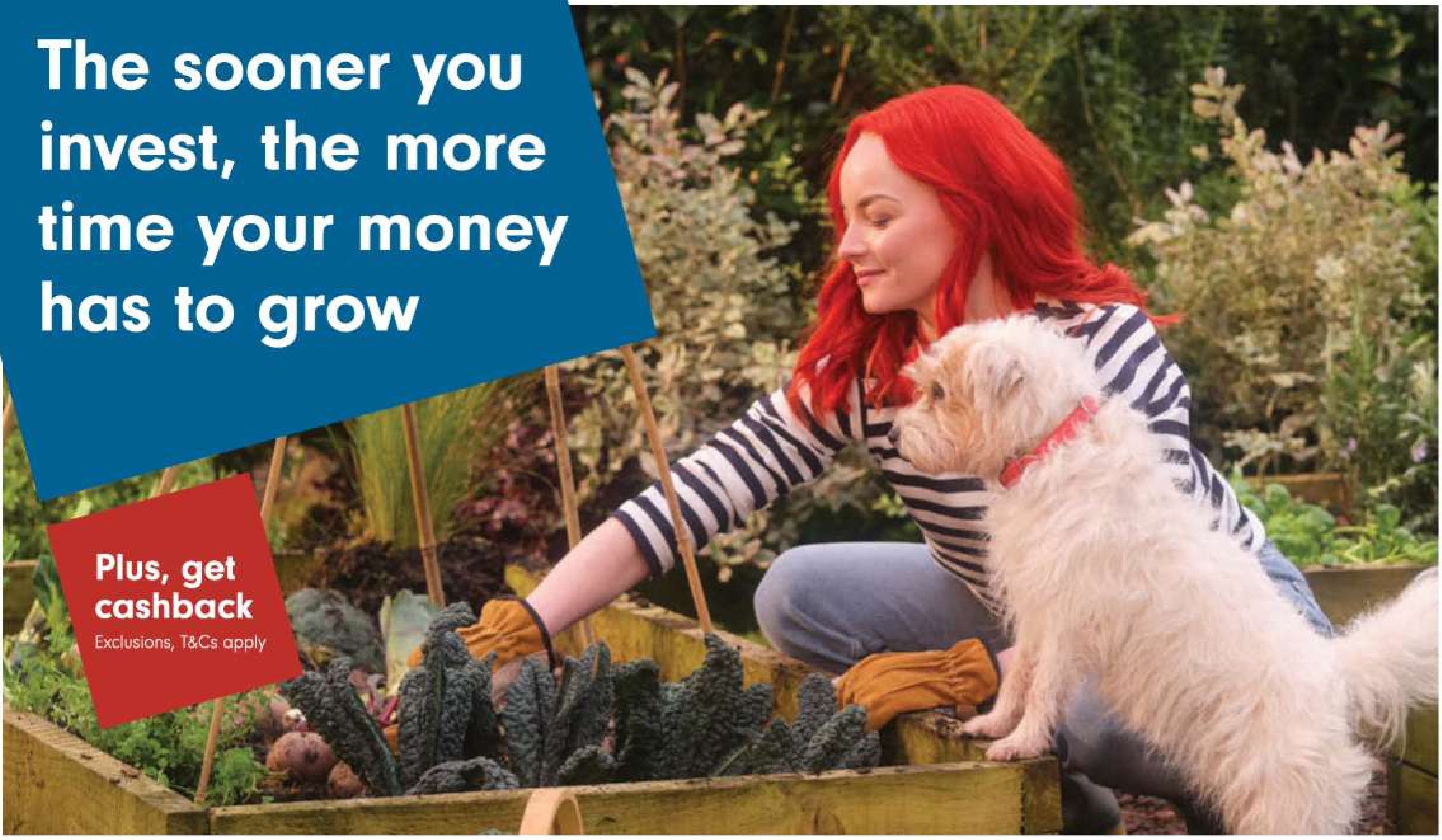
Prior to thermal runaway, it is preferential for each of the lithium-ion cells within a battery to conduct heat with its neighbours, helping to cool down any that may be approaching thermal runaway.

But once the situation reaches a certain tipping point, it would be desirable to instead isolate the dangerously hot cell so that its rising heat doesn't jeopardise other cells.

Wu Hui at Tsinghua University in Beijing and his colleagues have created a material that can be used to wrap individual cells and conducts heat well to maintain thermal equilibrium. But at a certain temperature – which can be tweaked to suit different batteries – water trapped in the material evaporates and leaves a skeleton that instead insulates the cells from each other to prevent the situation worsening.

The material is a hydrogel impregnated with tiny ceramic particles that can be formed into any shape to suit different battery designs (*ACS Nano*, doi.org/h4g6).

"In mainland China, we've had at least 7000 cases of batteries catching on fire in accidents in only one year," says Wu. "This situation is very serious." ▮



The sooner you invest, the more time your money has to grow

Plus, get cashback
Exclusions, T&Cs apply

Investing can help turn your future hopes into a reality. The longer you're invested, the greater chance you're giving your money to grow. But there are no guarantees.

- Benefit from long-term stock market growth potential
- Any gains reinvested multiply over time
- With our investment ideas and guidance, it's easy to get started

And you don't have to start big. Investing little and often is a great way to build up savings for the future.

Go to **fidelity.co.uk/offer25** or call **0800 99 55 33** to find out more about our tax-efficient Stocks and Shares ISA and Self-Invested Personal Pension (SIPP).

GET
£25

Get £25 cashback when you invest a lump sum or set up a regular savings plan online.

Offer ends 12 Sept '22. Exclusions, T&Cs apply.

Important information – The value of investments can go down as well as up, so you may get back less than you invest. Tax treatment depends on individual circumstances and all tax rules may change in the future. This information is not a personal recommendation for any particular investment. If you are unsure about the suitability of an investment you should speak to one of Fidelity's advisers or an authorised financial adviser of your choice.

ISAs | Pensions | Funds | Shares | Advice

Fidelity
INTERNATIONAL

Issued by Financial Administration Services Limited, authorised and regulated by the Financial Conduct Authority. Fidelity, Fidelity International, the Fidelity International logo and F symbol are trademarks of FIL Limited. UKM0522/370887/CSO10950/120922

New Scientist
Events

SAVE 33% WITH A SERIES TICKET*

ONLINE EVENT
BEING HUMAN SERIES

CAMILLA PANG
HOW TO BE A HUMAN

Thursday 8 September 2022
6-7pm BST, 1-2pm EDT and on demand

Humans are weird creatures, with obscure social customs, complex interpersonal relationships and baffling unwritten rules. However, scientist and author Camilla Pang is here to help us understand this strange species.

Diagnosed with autism spectrum disorder at the age of 8, Camilla has created her own manual for understanding humans, which won the Royal Society Insight Investment Science Book Prize in 2020. She is a champion for neurodiversity who recently published a book for children, revealing how as a child she used scientific ideas she understood to help explain social customs she didn't. Camilla believes all children should know it is completely normal to be perfectly weird. In fact, it is essential for growing up happy.

Find out more and book your ticket
newscientist.com/beinghuman

ALSO IN THE SERIES

BRENNA HASSETT
THE EVOLUTION OF CHILDHOOD
Available on demand

SVERKER JOHANSSON
THE DAWN OF LANGUAGE
Available on demand

ANNA MACHIN
WHY WE LOVE
Available on demand

*saving based on individual standard ticket price.

BEING HUMAN SERIES
CAMILLA PANG

Health

ADHD drugs may help Alzheimer's

MEDICATIONS for conditions like attention deficit hyperactivity disorder (ADHD) may improve cognition and decrease apathy in people with Alzheimer's disease.

People with Alzheimer's exhibit deterioration in part of the brain that produces noradrenaline, a neurotransmitter key to cognitive functions such as memory.

Michael David at Imperial College London and his colleagues have assessed 19 clinical trials of noradrenergic drugs used for ADHD, which boost noradrenaline levels. The trials included 1811 people with Alzheimer's disease or mild cognitive impairment. The drugs led to a small improvement in cognitive ability and a reduction in apathy, a common Alzheimer's symptom (*Journal of Neurology, Neurosurgery & Psychiatry*, doi.org/h4h8). **Grace Wade**

Palaeontology

Big dinosaur had tiny arms like *T. rex*

A NEWLY described dinosaur, *Meraxes gigas*, was big yet had small forelimbs, like *Tyrannosaurus rex*.

The dinosaur was unearthed in Argentina in 2012. Juan Ignacio Canale at the Ernesto Bachmann Paleontological Museum in Villa El Chocón, Argentina, and his colleagues say that, like *T. rex*, *M. gigas* had sharp teeth, a large head and tail and walked on two powerful legs, and it also had the distinctive proportionally small arms. But it lived during the Late Cretaceous epoch about 95 million years ago, roughly 20 million years before *T. rex*. The two weren't closely related, so such small forelimbs evolved at least twice (*Current Biology*, doi.org/gqggkk).

Canale thinks *M. gigas* may have used its arms to hold a partner during mating or to right itself after a fall. **Corryn Wetzel**

CRABBY TAXONOMIST (CC BY-NC-SA 2.0)

Marine biology

Protective goggles save shrimp from shock waves

SNAPPING shrimp have special eye wear that stops them hurting themselves when they stun their prey with shock waves.

The shrimp snap their claws to create supersonic blasts of pressure in the water that can incapacitate or kill prey. The snaps don't seem to affect the shrimp themselves, though, even when another shrimp snaps just next to their head, says Alexandra Kingston at the University of Tulsa in Oklahoma.

She and her colleagues have now investigated the role of the hard, transparent hoods that cover the brains and eyes of the shrimp.

The team surgically removed these orbital hoods from 60 bigclaw snapping shrimp (*Alpheus heterochaelis*) captured off the coast of South Carolina.

The behaviour of hoodless shrimp was essentially normal in the laboratory aquarium, as long as there was no snapping, says Kingston. But when a shrimp snapped, the hoodless crustaceans in the same aquarium immediately jolted, spun around or fell over.

When these shrimp tried to move back to their shelters, they often seemed unable to coordinate their limbs. By contrast, still-hooded bigclaw shrimp exposed to snaps in the lab behaved normally.

Pressure sensors revealed that the pressure inside the hood was about half what it was just outside the hood during a snap (*Current Biology*, doi.org/gqgf9h).

The key to the hood's protective effect may be in the hood's holes just below the eyes. The water trapped inside the hood gushed out of the holes during shock waves, potentially redirecting the energy from the blast away. **Christa Lesté-Lasserre**

Really brief

MARTIN POOLE/GETTY IMAGES

'Hangry' effect seen in real-world test

Some people really do seem to become irritable and angry when they are hungry, suggests real-world research. The study of 64 people found that hunger pangs were associated with 56 per cent of the variance in self-reported feelings of irritability (*PLoS One*, doi.org/h4g5).

Test run for dark matter detector

A 3.5-month test run this year has confirmed that the LUX-ZEPLIN dark matter detector in South Dakota is the world's most sensitive. The underground detector contains 10 tonnes of very pure liquid xenon, and should respond to any dark matter particles it encounters by producing bursts of light.

Meta's AI translates 204 languages

Facebook's owner, Meta, has released an AI that it says provides better text-based language translation than software alternatives. The No Language Left Behind AI can translate between 204 languages, including Friulian, which is spoken by about 600,000 people in northern Italy.

THE WORLD'S GREATEST FESTIVAL OF IDEAS & DISCOVERIES

New Scientist Live

7-9 OCTOBER 2022 | EXCEL LONDON AND ONLINE

FEATURE PARTNERS

SCHOOLS' DAY SPONSOR

MEDIA PARTNER

CHARITY PARTNER

MIND AND BODY STAGE

This stage is all about being human. We'll be delving into your body to uncover the secrets of the immune system, a new view of cancer and even the science behind faecal transplants. Speakers will explore the mysteries of the mind to answer why we fall for conspiracy theories and how our conscious brains perceive our bodies. Join us to discover amazing research to help you live a happier, healthier life. Talks on this stage will include:

THE DARK HISTORY AND TROUBLING PRESENT OF EUGENICS

ADAM RUTHERFORD Scientist, writer and broadcaster

REBEL CELL: CANCER – A NEW VIEW OF AN OLD DISEASE

KAT ARNEY Science writer and broadcaster

THE HUMAN BODY: DESIGN DISASTER

ROHIN FRANCIS Cardiologist, writer, comedian and creator of the YouTube channel Medlife Crisis

A BRIEF HISTORY OF YOUR BRAIN

EMMA BYRNE Author

NEW FRONTIERS OF THE IMMUNE SYSTEM

DANIEL DAVIS Imperial College London

BELIEVING THE UNBELIEVABLE: AN EVOLUTIONARY PERSPECTIVE ON PARANOIA AND CONSPIRACY THINKING

NICHOLA RAIHANI UCL

For the full programme and to book your tickets visit

newscientist.com/ns0710

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **One Earth Conservation**

One Earth Conversation's Director, Dr. Rev. LoraKim Joyner, showing villagers in Central America how to care for parrots

Help save wild parrots

Parrots are one of the most at risk animals in the world, with 29% of species listed as endangered or threatened, and 58% in decline, from the pet trade and habitat loss. In many areas, the poaching rate is 100% - no chicks escape the illegal wildlife trade. About 90% of birds die after capture within one year, with survivors usually doomed to a life of low welfare, including health and nutritional problems, social isolation, and the inability to engage in natural behaviors.

This results in tremendous loss of life and suffering, while also rendering human communities bereft of opportunity, safety, and health. People who live near wild parrots are often marginalized and live in poverty, resorting to climbing trees to trap parrots at the risk of injury or death for income driven by the demand for pets. However, many desire other opportunities and One Earth Conservation (OEC) uses integrated conservation strategies to help people, parrots, and ecosystems flourish.

OEC is a small U.S.-based non-profit that supports parrots and marginalized people in Central and South America. We go into countries like Guatemala, Guyana, Honduras, Nicaragua, Paraguay, and Suriname, which receive little attention and resources and where parrots are endangered or threatened. In these places, we assist local, mostly Indigenous people, so they can eventually, and sustainably, conduct parrot conservation on their own. We empower people, including former poachers, by training them to protect wild parrots.

Our Honduran Scarlet Macaw Project is the largest wild parrot conservation area in the world – about 500,000 acres – protected by community patrols. Generally, OEC works with local villages and NGOs, other conservation organizations, and government agencies. Our partners begin projects with complete ownership and, eventually, learn to lead conservation efforts through OEC's capacity building programs. With our partners, we have reduced local scarlet macaw poaching in Honduras from 100% to about 20%.

In addition to monitoring and researching wild parrots, our projects provide stipends to partners on the ground, so they can engage in meaningful and life-saving work. Results have been astounding given the multiple threats against people and parrots – including threats and attempts to assassinate some of our partners – though the future of parrots remains tenuous in many locations.

Want to help?

Our work is urgent, relentless, and sometimes – for parrots and people – life or death. Follow us, visit our website, and consider donating to support our work.

Oneearthconservation.org/donate
facebook.com/oneearthconservationss
@OneEarthCons on Instagram
@OneEarthCon on Twitter

Do you need your signal boosted?

If you are a charitable organisation working in STEM, science, medicine, technology or conservation, and would like to find out more about this project contact Jacqui McCarron on jacqui.mccarron@newscientist.com

Views

The columnist
A new UK coal mine would be wrong, says **Adam Vaughan** p28

Aperture
Grisly objects from a new exhibition on anatomical study p30

Letters
Changing seasons already take their toll on people p32

Culture
Do bees have minds of their own and are they conscious? p34

Culture
A new symphony makes music from black hole data p36

Comment

Black market birds

Jurassic World Dominion's dinosaur trafficking isn't far from a feathered reality. The illegal trade in birds must stop, says **Raj Tawney**

SIMONE ROTELLA

"IT'S not about us," Alan Grant (played by Sam Neill) says to his fellow crusaders in one of the culminating scenes of *Jurassic World Dominion*, as they escape a research centre in ruins, terrorised by a *Giganotosaurus* that is about to have a showdown with a *Therizinosaurus* and a *Tyrannosaurus rex*. Fitting words for the final chapter in a movie franchise that, for three decades, has tried its best to send an environmentally conscious message through a Hollywood blockbuster lens.

In the series' finale, director and co-screenwriter Colin Trevorrow filters the corruption of big pharma and biotech conglomerates through one evil overlord, who goes to great lengths to capture a baby dinosaur for his "sanctuary" in Italy's Dolomite mountains, exposing an underground of black market dinosaur trading.

Although the illegal hunting and trading of prehistoric creatures is fictional, this storyline rings alarmingly true for their direct descendants: birds. According to a report from BirdLife International, 25 million birds were illegally killed in the Mediterranean region in 2014, with Italy accounting for 5.6 million of them – the most of any of the European Union's Mediterranean member states.

Illegal trapping of birds, particularly songbirds, also occurs in smaller countries, including Bulgaria, Romania, Serbia and Montenegro, before they are exported to northern Italy to be used as either food or pets.

Elsewhere, the African grey parrot has become one of the African animals most affected by the illegal wildlife trade, due to its desirability as a pet. One population has decreased by 90 per cent since the 1990s, yet demand continues to increase.

At the beginning of the covid-19 pandemic, some countries, including China and Vietnam, put a wildlife trade ban in place in an attempt to curb the coronavirus, temporarily slowing down the estimated $23 billion international black market in illegal wildlife trafficking. But further sanctions are desperately needed in those countries most accountable for illegal activity.

WWF Italy recently reported that the country is a key crossroads for the trafficking of protected species and wildlife crimes in general. Although Italy launched a national anti-poaching action plan five years ago, it has no centralised database on crimes against nature, nor monitoring of any kind.

In 2021, however, the Italian government did place a ban on the importation of exotic animals (parrots, armadillos and other creatures) in an effort to prevent future breakouts of deadly diseases. Italy has also introduced a ban on fur farming and hunting trophies of protected species.

And on the ground, volunteers from the Italian League for Bird Protection (LIPU) have been monitoring hunting areas and bird fairs, reporting and seizing a variety of species, including songbirds and turtle doves, as well as helping birds suffering from gunshot wounds.

Whether or not Trevorrow was aware of the problems facing wildlife globally as he made *Jurassic World Dominion*, he has alluded to its genetically cloned animals experiencing the same struggles as those in the real world. "We have animals in zoos," he told *Total Film*. "We weaponize them. We put them in our homes as pets. We sell them in markets. So all of these different realities are in this film."

It is tough to calibrate whether *Jurassic Park Dominion*'s highlighting of black market animal trading has trickled down to the public, but worldwide box office sales neared $400 million during its first week. It is still a profit game for humanity, but let's hope those sales help raise public awareness of a very real issue. ■

Raj Tawney writes about humanity's impact on the natural world. rajtawney.com

No planet B

No climate for coal The UK's new levelling up secretary must not let a new coal mine in Cumbria go ahead. It would be indefensible on climate grounds, says **Adam Vaughan**

Adam Vaughan is chief reporter at *New Scientist*. He covers everything from the environment and energy to covid-19 and other key science stories

Adam's week

What I'm reading
Four Thousand Weeks *by Oliver Burkeman. A tribute to finitude and the "joy of missing out".*

What I'm watching
Season three of For All Mankind. *It's the Mars season! Plus the counterfactual TV moments are a joy.*

What I'm working on
A story about the introduction of bison to the UK.

"CONSIGN coal to history," said UK prime minister Boris Johnson, responding to a landmark climate science report last year. A few months later at the COP26 climate summit, the world committed to accelerating the "phase-out" of coal power. Just last month, John Gummer, the chair of the UK's independent Climate Change Committee (CCC), said: "As far as the coal mine in Cumbria is concerned, let's be absolutely clear, it is absolutely indefensible."

A political decision on that mine had been due on 7 July, but was delayed amid the chaos of Johnson's resignation. The choice will now be near the top of the in tray for Greg Clark, who has been appointed the UK's new secretary of state for the Department of Levelling Up, Housing and Communities, following the sacking of Michael Gove.

If given the green light, the mine would be built by West Cumbria Mining, backed by an Australian private equity group. It would produce 2.8 million tonnes of coking coal for use in steel-making each year, and create 532 jobs. The kicker? The coal would release the equivalent of the UK's carbon dioxide emissions for a whole year, assuming it operated for 50 years.

Advocates say Cumbria needs the jobs and UK steel-makers would otherwise just import the coal. Yet four-fifths would be exported. Even the remaining fifth appears unwelcome. British Steel, one of the UK's primary steel-makers, has said the coal's sulphur content means it wouldn't want it. That leaves Tata Steel as the only potential customer. Leading materials scientists question the demand too.

Meanwhile, the industry is exploring "green steel" innovations beyond coking coal, such as the use of hydrogen and greater use of electric arc furnaces.

So what about jobs? Cumbria, like other parts of the UK, needs them. Yet one report estimates that investing in renewables and other "green industries" instead could create 9000 jobs. And the results of a UK government auction on 7 July, which secured investment in 93 renewable energy projects to power millions of homes, are another reminder that there are cleaner ways to make new jobs.

The coal mine might seem like a parochial planning matter. But it is worth pausing to consider how pivotal "old king coal" has been in the UK's history. The country's industrial revolution was built on the most carbon-intensive of fossil fuels. Coal was supplying more than two fifths of electricity just one decade ago. Yet the UK has phased it out at unprecedented speed and spearheaded an international alliance to do the same. "Coal, cars, cash and trees" were Johnson's sound-bite priorities at COP26.

> **"Now is a crucial time for governments to ensure this coal revival is just a brief blip, not the start of a long-term trend"**

The decision Clark makes as levelling up secretary will send a message to the world. The UK, even though it needs to do much more to cut emissions, is still rightly seen as a climate change leader worldwide. "It'd be a big blow for the UK's climate reputation", were the secretary to give a green light, says Rebecca Willis at Lancaster University, UK.

Right now, leadership on coal matters. Globally, but especially in Europe, many countries are turning to coal in the face of high gas prices and energy security concerns triggered by Russia's invasion of Ukraine. Germany has reversed policies to burn less coal so it can fill up gas storage facilities before autumn and winter. Austria is reopening a closed coal plant, France is thinking of doing the same, and the Netherlands has lifted a cap on coal. The UK has agreed to postpone the closure of two coal power stations and is in talks to defer one more.

These temporary steps are bad climate news, for sure. But we should keep them in perspective. The short extension for a few old UK coal plants that may only be used on a handful of cold, windless days this winter will emit relatively tiny amounts of CO_2. "I'm not at all concerned by brief extensions to coal plants that are used hardly at all during the year," Chris Stark, chief executive of the CCC, says.

Now is a crucial time for governments to ensure this coal revival is just a brief blip, not the start of a long-term trend. Any decisions that lock in more fossil fuel extraction – such as a new coal mine that will operate for decades – would fly in the face of the International Energy Agency's influential 2021 report on how the world should get to net zero.

The political oxygen for climate change action may be in short supply globally now, but the imperative to act hasn't gone away. That is why citizens are voting out governments that are climate laggards, as Australians demonstrated in May. Brazilians may yet do the same in October. Clark may want to weigh how his decision on the coal mine, now due by 17 August, will be received by UK citizens concerned about climate change, who will get their vote by January 2025 at the latest. ■

Graham Lawton is away. Up next week: Annalee Newitz

NewScientist
Discovery Tours

Last few places on group tours departing soon

Experience science in person and up close

Ancient caves, human origins

23 August and 6 September | 7 days

Step into the past to see how our ancestors lived and admire ancient cave art, plus enjoy the sights and tastes of Spain today.

Renaissance astronomy in Prague

10 September | 6 days

Discover the secrets of renowned astronomers Kepler and Brahe in Prague, the stunning city of a hundred spires, and stargaze at the Štefánik Observatory.

Wildlife of Madagascar

10 September | 13 days

Join park rangers on patrol in Madagascar's stunning lemur-packed forests, and enjoy bush camps, canoeing and sunset walks.

Neanderthal origins

2 and 16 September | 10 days

Journey back in time to key Neanderthal sites in southern France and see some of the oldest stone tools, art objects and cave paintings.

Explore more fascinating tours, cruises and expeditions online
newscientist.com/tours

ANATOMICAL MUSEUM COLLECTION, UNIVERSITY OF EDINBURGH; NATIONAL MUSEUMS SCOTLAND; COURTESY OF AMSTERDAM MUSEUM

A grisly history

FROM unorthodox equipment to skeletal remains, this selection of objects from the exhibition Anatomy: A Matter of Life and Death at the National Museum of Scotland in Edinburgh reveals the fascinating – and at times disturbing – 500-year history of anatomical study.

On the far left is the skeleton of serial killer William Burke. Burke and his accomplice, William Hare, committed a string of 16 murders in Edinburgh in 1828, selling the corpses to Robert Knox, an anatomist who would dissect the bodies during his lectures. Edinburgh had been one of the leading medical research centres in Europe from the 18th century, so "body-snatching" was quite common at the time, making up for the shortage in cadavers available for dissection.

Burke and Hare's victims are memorialised in the top centre image, showing a set of miniature, carved figures inside coffins, found hidden on Arthur's Seat in Edinburgh in 1836. An anatomy lecture in Amsterdam is depicted in Cornelis Troost's 1728 painting (right, centre), set up to portray the surgeons in a favourable light despite the unsavoury reality.

The bottom-centre image shows a toolbox of 19th-century surgical instruments for dissection, including an amputation saw, while jars from the 18th and early 19th centuries, used to hold leeches for removing blood, are shown at the bottom right. Despite the understanding of human physiology that dissections provided, they didn't immediately lead to better care for people in the 17th and 18th centuries, many of whom used charms like those shown top right to ward off illness instead.

The exhibition is showing until 30 October. ▮

Gege Li

Editor's pick

Changing seasons already take their toll on people

25 June, p 42

From John Magrath,
Botley, Oxfordshire, UK

Failing synchrony of crucial natural events due to global heating isn't only causing havoc for animals and plants, it is also already having destabilising consequences for many low-income communities.

In 2009, I co-wrote the report *What Happened to the Seasons?* for Oxfam, based on observations in 15 lower-income countries. There was agreement that marked seasonal shifts were occurring in temperature, in ecosystem responses and in the timing, intensity and quantity of rainfall.

Low-income communities described: shorter and more interrupted growing seasons, which reduced agricultural production; greater unpredictability, which necessitated more investment of time, energy and scarce resources; and existential shocks to belief systems and cultural practices, involving bewilderment, disorientation and a sense of loss. These changes were strengthening trends to move out of agriculture and rural areas.

We concluded that for many of the world's lowest-income people, these changes already constituted a serious additional threat to food security. No doubt this is worse now.

If time isn't real, then what about space-time?

18 June, p 38

From Ian Machell,
Staverton, Wiltshire, UK

Despite all the hype, there is no escaping the fact that time has no tangible, physical properties, so can only exist as an abstract concept. It is derived by counting some natural astronomical and subatomic cycles to build calendars and clocks for the purpose of timekeeping.

Because space-time is only a mathematical model that relies on the abstract concept of time, we should question whether it exists as an entity in its own right, too.

The US was once close to adopting the metric system

18 June, p 34

From Robert Checchio,
Dunellen, New Jersey, US

Regarding Chris Stokel-Walker's review of *Beyond Measure*, opposition to the metric system hasn't been limited to the UK.

Back in the 1970s, the US Congress passed the Metric Conversion Act, which declared metric as the preferred system, and the country soon began a programme of testing road signs marked in kilometres, a first step towards helping citizens to accept the metric system.

But action by Charles Grassley, a Republican congressman, killed that effort. "Forcing the American people to convert to the metric system goes against our democratic principles," he said.

Apparently, retaining a system that hinders the ability to interact with an increasingly globalised marketplace was seen by politicians as a measure of US exceptionalism. It still is.

Lockdown's lessons lead to climate pessimism

Letters, 25 June

From Steve Blyth,
Roade, Northamptonshire, UK

If Perry Bebbington cites correct figures for emissions reduction during lockdowns, it seems that limiting temperature rise to 2°C will require cutbacks in economic activity to medieval levels. It is unlikely that industry, let alone politicians and the populace, will willingly accept the associated changes, especially in living standards. Of course, climate consequences from a temperature rise of 2°C or more may be equally unacceptable – but unavoidable.

Oil giants have the might to help solve our problems

25 June, p 27

From Mike Clarke,
Castle Hedingham, Essex, UK

If we are to maintain and support the world population in a modern lifestyle, we need to find ways to produce hydrocarbon-based products from an alternative, sustainable source at a scale similar to our current oil-based processes. The only organisations that currently have the resources, know-how and knowledge to do this at large scale are those same industries that currently use oil-based technologies.

From Patrick O'Connor,
Meppershall, Bedfordshire, UK

Zak Coleman argues that universities must stop taking research money from the fossil fuel industry because of "a climate crisis that those firms are driving".

Those firms are providing us with necessary fuels, production of which isn't illegal or immoral. It provides work for many, income for shareholders, tax and even research funding for universities.

Just imagine a cold, dark world with no heating, electrical power, transport or production.

Urbanites are greener than rural communities

Letters, 25 June

From Dave Appleby,
Eastbourne, East Sussex, UK

John Fewster implies that "dense communities of urbanites" use resources more mindlessly than "pastoral folk". As an urbanite, I live in a flat whose carbon footprint is likely to be far lower than that of a detached home in the country.

Furthermore, while I recognise that my "food miles" are likely to be greater, I walk to the shops and can commute by bus or train, while many non-urbanites must often travel long distances by car. I suspect the overall environmental impact per capita of a dense community is lower than that of their rural neighbours.

Why nuclear is no answer to short-term dilemmas

Letters, 25 June

From Andrew Taubman,
Sydney, Australia

Graham Reynolds posits a false dichotomy: calamitous global warming or "safe" nuclear waste. Building hundreds or thousands of nuclear reactors in the next 30 years would worsen global warming due to the front-loading of their emissions from construction and concrete, any putative benefits only coming when it is too late. Existing nuclear plants should be run for as long as it is safe to do so, but no new ones should be, or need to be, built.

From Geoffrey Patton,
Silver Spring, Maryland, US

It is a misconception that any particular source of cheap energy can get us out of the climate crisis. Cheap energy only drives more consumption, and so resource extraction. Instead, we need sustainable, steady-state consumption and population.

For the record

▮ Heritable genome editing is banned in many countries, but not globally (2 July, p 18).

▮ In our "The longevity diet" box in our piece on age-defying diets (2 July, p 38), we shouldn't have mentioned complete fasting. Please don't attempt any form of fasting without medical supervision.

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters
Letters sent to New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT will be delayed

University of Glasgow

CHANGE YOUR FUTURE AT A WORLD TOP 100 UNIVERSITY

- Online postgraduate healthcare programmes
- Help shape the future of healthcare
- Inspire your career

landing.online.gla.ac.uk/health

WORLD CHANGERS WELCOME

University of Glasgow charity number SC004401

Micropathology Ltd

Tel 24hrs: +44 (0) 24 - 76 – 323222
Fax / Ans: +44 (0) 24 - 76 - 323333

University of Warwick Science Park, Venture Centre, Sir William Lyons Road, Coventry CV4 7EZ
Website: www.micropathology.com E-mail: info@micropathology.com

GRADUATE SCIENTISTS - MOLECULAR DIAGNOSTICS

We provide a clinically supported service for the rapid diagnosis, research and management of infectious disease.

We are seeking motivated graduates with molecular experience to work within our laboratories.

Daily duties will include performing PCR, result interpretation and administrative tasks. Appointees will assume responsibilities for service improvement. Occasional part time weekend attendance may be required.

Two posts are available; one centred on the company's extensive assays and another focussed on our nucleic acid extraction protocols for patient samples.

Candidates will possess an undergraduate degree in biological/medical sciences. Candidates must have good literacy, IT and mathematical skills. A solid scientific knowledge is essential. Previous experience in clinical microbiology/familiarity with quality management systems would be helpful (the laboratory is accredited to UKAS standards).

Applicants must be legally entitled to work in the UK.

Successful applicants will be appointed for a probationary period and subject to satisfactory performance will be offered a permanent post. Pay and pension will be competitive and commensurate with skills/experience.

Applications (CV and hand-written covering letter) should be submitted to Helen Healy at the address above. Information requests should be sent to **personnel@micropathology.com**

Early applications encouraged. Direct applications only. Closes end of July 2022.

To bee or not to bee

Does a bee have a mind of its own, awareness of the world, basic emotions and intelligence? **Alun Anderson** explores a brave new book that makes the case

Book

The Mind of a Bee

Lars Chittka

Princeton University Press

ARE we ready for the radical message that an insect may have a form of consciousness? I am not sure.

Most of *The Mind of a Bee* by Lars Chittka, professor of sensory and behavioural ecology at Queen Mary University of London, will upset no one: it is an entrancing journey through the senses and life struggles of bees. The shock comes in the final chapter, when he argues that a bee may have a "mind" that both thinks and feels.

Consciousness used to be seen as uniquely human, but then other mammals, starting with primates, were admitted to the club. Now many consider that an invertebrate, the octopus, may be aware. To include an insect in this consciousness club would be another prodigious leap: from being almost alone, we would find ourselves in a vast sea of sentience.

That is radical and risks inviting ridicule. But the evidence is there, and might force us to rethink our duty towards animals, as Chittka's afterword explains.

The bulk of the book takes an approach that I loved. A sub-heading in the introduction reads: "Why imagining other minds is important for understanding them." Chittka continues that some philosophers see "no point in trying to imagine such strange alternative worlds. I disagree..."

Me too. Scientists rightly fear anthropomorphism, but used skilfully, the imagination yields understanding. So let's accept Chittka's invitation to "picture what it is like to be a bee".

PETER ATKINSON/500PX/GETTY IMAGES

Bees visit about 1000 of the "right" flowers to make a drop of honey

First, put on your exoskeleton and enjoy your wings – you can fly all day, faster than a human can run. Your eyes are less sharp now, but respond faster: electric lights flicker rather than glow. You are able to sense Earth's magnetic field, and can see ultraviolet light and a range of new colours.

Antennae stick out from your head and can be moved around to smell, taste, hear and analyse shapes. The subtlest flower scents are detected so quickly that you can run your antennae over a surface and trace a pattern of perfumes into what Chittka calls an "odour movie".

"Scientists rightly fear anthropomorphism, but used skilfully, the imagination yields understanding"

But to discover what is on a bee's "mind", you must go further, and imagine yourself living a bee's life, experiencing its challenges.

On day one as a forager, you start by making looping flights near the hive, so that you can recognise home. Fail and you die. Then it is off to work. You must find food sources quickly, remember their location, the best routes to them and the way home. You have to learn when particular flowers make nectar and master new manipulative skills to reach food in different flower shapes.

You will also need to work fast, since you must visit some 1000 flowers, rejecting 5000 others as not worthwhile, and fly 10 kilometres or so to generate a drop of honey. Not easy. Humans struggle to shop thriftily when a few supermarkets offer different bargains at different times – a bee must do far better while putting in 12 to 16-hour shifts.

This "experiment" shows that throughout your foraging life you have to learn fast, solve problems, plan and tap into memories. You need to be smart. A bee isn't the kit of hard-wired, pre-fabricated "instincts" you might think.

Exploring more of the bee's cognitive skills, we discover from Chittka that bees can count. Not as humans do, by identifying small numbers at a glance, but by ticking off items sequentially. They can focus their attention and learn rules to classify flower types, and more abstract rules, like "same" or "different". By watching other bees, they also learn not only which flower types to visit, but the tricks needed to get at the nectar.

A bumblebee can even learn to pull a string to access a sugar source, and another bee can pick up that skill by watching her. This new skill may spread throughout a whole colony, which astonished me. But from the bee's perspective, such cognitive tricks are just what are needed to survive.

If we accept that bees are smart, can we also consider they might be conscious? This is quite a stretch. It is one thing to imagine a bee's mind in order to build a picture of its daily life, but quite another to claim that it really has a "mind" that both thinks and feels, that is aware and can potentially suffer.

Chittka knows that he is in speculative territory. No one can prove that a creature is conscious. But the bee has some attributes considered critical for "mind". For example, "mind" surely requires integrating information from the senses and body into a bigger picture. Bumblebees that have learned to distinguish between two objects by handling them in the dark can recognise them visually, suggesting they make representations of objects that don't depend on the sense used.

They also appear aware of their own bodies. After carefully examining a narrow gap, a bumblebee can angle its body, or fly sideways, to pass through it. Additionally, bees seem to display metacognition (meaning that they know what they know), have emotional states, feel pain and have different sleep phases.

The list grows, although a bee's mind may be hard for us to grasp. With their fast senses, bees might differ profoundly from us in their perception of time, for example.

There is much more to Chittka's argument that must be left for interested readers to discover. *The Mind of a Bee* is a serious book that requires deep thought. My bet is that a few readers will end up convinced, a few will be indignant and most, like me, will be intrigued and hoping for the birth of a new field of comparative consciousness, in which many such "alien" minds are explored. That would be a fine outcome for a brave book at the frontiers of science. ▮

Alun Anderson is emeritus editor of *New Scientist* and a writer based in London.

For more on bees, turn to page 42

Lost in meta-space

Grappling with the elusive metaverse makes for a mixed read, finds **Chris Stokel-Walker**

Book
The Metaverse
Matthew Ball
Liveright

BILLIONS of dollars and millions of hours have been committed to the metaverse, the buzzy vision of a digital world that promises to transform human life. Yet for all the hype, we have yet to pin down exactly what it will be and why it will matter.

One of the first to take a stab at explaining it is Matthew Ball, CEO of US venture capital fund, Epyllion. *The Metaverse: And how it will revolutionize everything* builds on Ball's punchy essays about this virtual future, which are much loved by the tech community. However, in leaping from long essays to a 352-page book, his writing loses some of the lustre for which he has been praised.

Ball also struggles to define his readership and their level of expertise. Many general readers won't make it through the tonally confusing first section. Here, information washes over you with little explanation of the thinking behind the way it is presented. Ball veers from a generalised picture of the metaverse and how to access it to manual-like details about how to render environments in real-time. Readers are expected to be know-nothings and know-it-alls simultaneously.

The basics are often not that basic. Ball says, seemingly without irony, that "in a simplified sense, the metaverse era can be thought of as involving the use of bits to produce 3D alarm clocks made of virtual atoms". This is part of a metaphor that clearly got lost in translation. I also got lost – and I write about the metaverse a lot.

For some, that would be enough reason to put the book down. But persevere and see the fog clear – slowly. Chapters on bringing the various iterations of the developing metaverse together, making them interact, and the hardware required, are lucid and logical.

The third section is even better. Ball prophesies about when, where and how the metaverse might arrive, and what it could do to our lives. Its strength is testament to years of thinking deeply about the area.

However, much of the book belies that expertise. It may be the format: *The Metaverse* feels like extended thematic essays looped together, rather than building a cohesive narrative.

Throughout, intellectual nuggets await those willing to plough on: for example, there are great insights on the risks of tech monopolisation. But it takes willpower to find the gold among the grit. ▮

Chris Stokel-Walker is a writer based in Newcastle, UK

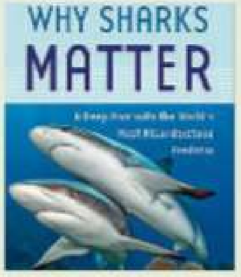
We hear a lot about the potential of the metaverse, but what is it and when will it arrive?

ROCKLIGHTS/ALAMY

Don't miss

Visit

The Handshake is over 7 million years old, says palaeoanthropologist, explorer and comic Ella Al-Shamahi. She will explain the secrets of this most ancient and universal greeting at the Royal Institution, London, at 7pm BST on 21 July.



Read

Why Sharks Matter to us, the oceans and the marine economy is a subject of concern for David Shiffman, at the University of Arizona. Saving the imperilled predator will require a serious rethink of its image. Available to buy in the UK from 19 July.

Visit

The Future of Ageing makes the case that now is the best time to be old, with robots, smart rooms and more. Timely, since 25 per cent of the UK will be over 60 by 2040. At the Design Museum, London, from 20 July.

T&B: ANNA SHVETS/PEXELS; CHRIS REEVE

Music from the black hole

Will an extraordinary work called *Black Hole Symphony* be a triumph for science? **Bethan Ackerley** takes a peek at this upcoming concert series

Music

Black Hole Symphony

David Ibbett

Museum of Science in Boston, Massachusetts, and Multiverse Concert Series

On 28 July and 25 August

TAKE a second to imagine the sound of the cosmos. What comes to mind? Is it the howling winds of a far-flung exoplanet? The roiling eruptions at the surface of the sun? Or simply the nothingness that would greet you in the boundless vacuum of space?

In the absence of recordings of the "real" sounds of our universe, you may well have thought in terms of music. Some of our most potent attempts to represent these sounds creatively have been made through musical composition: think of the sweeping strings and martial brass of Gustav Holst's *The Planets*, or the warbling electronica of *Forbidden Planet*. Yet these efforts are typically figurative, divorced as they are from the material reality of space.

So what happens if you inject some real science into the creative mix? *Black Hole Symphony,* which was penned by composer David Ibbett and is due to be performed by an orchestra at the Museum of Science in Boston, Massachusetts, is doing exactly that.

The work cleverly translates cutting-edge research on black holes into an electro-symphonic score with five movements. It combines narration from scientists with immersive, planetarium-style visuals based on images taken by scientific instruments, including the Event Horizon Telescope, a large array made from a global network of radio telescopes, which took the first image of a black hole.

These elements create a voyage through the features of a black hole, one of the most enigmatic phenomena in our universe, from the swirling torus of dust that surrounds it to the beams of ionised matter it emits, which are known as relativistic jets.

Capturing this complexity was crucial to Ibbett. "It's not just a sort of single homogenous experience of getting sucked into a void," he says. "You have these different regions of the dust and rock and superheated clouds, shining with echoes of light. The disc itself, the gravitational lensing – it's just a really rich story that needed to be told."

Ibbett worked with researchers at the Center for Astrophysics and the Black Hole Initiative, both in Cambridge, Massachusetts, to transform the latest black hole data into music.

Data sonification is a small but rich field in which information – which can be about anything from the crystallisation patterns of salt to the effects of climate change on cedar trees – is conveyed through sonic qualities like pitch, tempo or rhythm.

"One section of the symphony is drawn from a simulation of two black holes merging"

The harmonic structure of *Black Hole Symphony* is built around the electromagnetic emissions of a black hole and its surrounding phenomena, with radio waves pitched low and gamma rays high.

RAJARAJAN PALANIMURUGAN

David Ibbett set out to capture black hole complexity in sound

Another section of the piece, drawn from a simulation of two black holes merging, allows the stretching and squeezing of space-time by gravitational waves to dictate the glissando (sliding between two notes) of a trombone.

Key to bringing the composition to life was finding instruments that seem to fit the "character" of the black hole's components: the relativistic jets become a distorted electric guitar, for example, while the torus is represented by the French horn.

It is here that Ibbett has played with our existing canon of "space sounds", subverting expectations at times and playing it straight at others. The symphony's opening strains, for instance, would feel perfectly at home in the filmed version of a space opera.

"I hope that we got all those cliché moments in the mix, but they're put through their paces because of the data that goes into the piece," says Ibbett. "That sends the music down a path that you wouldn't otherwise have gone down, and hopefully results in something new."

In its dedication to the new and unknown, *Black Hole Symphony* inspires as much as it informs. The music looks on to the future of astrophysics in a passage that represents the Laser Interferometer Space Antenna, which will one day hunt down gravitational waves.

"We want to leave people with an appreciation, a wonder and curiosity about the universe and about black holes, but also about music and art and how it brings us all together," says Ibbett. "It's something that we can celebrate without any caveat."

To listen to preview clips of *Black Hole Symphony*, head to blackholesymphony.com. ▮

New Scientist

Diversity Internship

Learn to be a science journalist

New Scientist is the world's most popular weekly science and technology magazine. Founded in 1956 for "all those interested in scientific discovery and its social consequences", the publication's journalists cover international news from a scientific standpoint and ask the biggest-picture questions about life, the universe and what it means to be human.

These fundamental mysteries are of interest to everyone, whatever their background. But both science and journalism suffer from a lack of diversity, with many talented individuals and valuable perspectives excluded or lost from these fields.

To address this, *New Scientist* is offering a learning and development opportunity open to anyone from an ethnic minority background.

Successful applicants will begin a six-month internship in October 2022. The internship will pay the 2022 London Living Wage and be based in our High Street Kensington office, London.

This year, we are recruiting two news interns and one video intern. News interns will receive one-to-one mentoring from an experienced journalist and on-the-job training in news and features writing, plus subediting and audience engagement, with your work published both online and in print. You will leave the internship with a portfolio of published work, ready to start a career in science journalism – as many of our interns have done.

Our video intern will be based in our video team and will learn how to produce scientific videos from idea to publication. You will source footage from researchers, script and edit short-form news videos and publish them across our online and social media platforms. Alongside this you will have the opportunity to come with us on shoots and be trained in camerawork. You will also receive foundational training in news writing and subediting, and will leave the internship with a showreel that demonstrates your skills.

The only entry requirements are that you will have completed a science, technology, engineering, mathematics or computing degree by the start of the internship, and that you have a demonstrable interest in writing, video editing or journalism.

How to apply

We ask applicants to submit 200 words explaining how they meet our requirements (see left) and why they are the right person for this internship. We also ask candidates to write an article, between 500 and 800 words long, on a recent scientific discovery, or create a 2 to 3-minute video on a scientific topic that interests them.

The closing date for applications is 22 July.

To apply, please visit tinyurl.com/nsinternship2022

The internship is a positive action scheme, under the Equality Act 2010.

M-IMAGEPHOTOGRAPHY/ISTOCK

INTO THE BLUE

UNSPLASH/SAM WERMUT

A day out in nature is wonderfully good for us. But for the best benefits, don't opt for green space, head for the water, says **Catherine de Lange**

WHETHER it is a bracing sea breeze, the gentle lapping of waves or the glint of sunshine on a rippling surface, there is something deeply restorative about being in or near water. The Victorians knew this, prescribing sea air as a treatment for melancholy. So did the French, who, for centuries, sent people with ailments to natural springs. Now scientists are catching up.

We recognise the benefits of being out in nature more keenly than ever these days. Hundreds of studies that catalogue the positive effects are being translated into health policies and urban redevelopment projects that aim to nudge people into the great outdoors and, in doing so, alleviate many of the health burdens that accompany modern life.

But as we rush off to embrace the wilds, and the accompanying boost to our health and mental well-being, we might want to stop and consider exactly where we are heading. While we are becoming increasingly preoccupied with spending time in green spaces, fresh research is showing that blue spaces – areas next to water – might give us even more benefits.

The idea that nature can give us a mental pick-me-up is nothing new. The Japanese practice of *shinrin-yoku*, or "forest bathing", is an established tradition of connecting with nature through all the senses. It became popular in the 1980s, after studies demonstrated its calming effects on both body and mind, reducing heart rate, stress hormones and blood pressure.

Epidemiological studies have since backed up the idea, showing that people who live in greener areas tend to have better mental health. Until fairly recently, however, it wasn't clear whether this was really thanks to nature or simply because people who are already healthier for other reasons choose to live in greener areas. Mathew White at the University of Exeter, UK, and his colleagues wanted to find out, so, in 2013, they examined data on more than 1000 people in England who moved house. They found significant benefits to mental well-being for people who relocated to greener urban areas. For the first time, there was direct support for the idea that green spaces were making people feel less blue.

We now have evidence that the mental boost that comes with connecting to nature goes way beyond happiness and well-being. The list of other attributes that can be improved covers attention, creativity, memory and more. It can also aid sleep, help people experiencing anxiety or depression and ameliorate some symptoms of conditions such as attention deficit hyperactivity disorder. These findings haven't been lost on authorities, with governments pushing for more green spaces in urban design and some doctors even prescribing time in nature for their patients.

But by focusing all this attention on the power of green spaces, are we missing a trick? The idea that blue spaces are better than green first began to emerge about a decade ago, when Susana Mourato at the London School of Economics and George Mackerron at the University of Sussex, UK, published an innovative study. They recruited more than 20,000 people across the UK to use a smartphone app that sent them a questionnaire about how they were feeling at random times. The participants had to submit their answers then and there.

The researchers collected more than a million responses and, by looking at phone location data, found that people were substantially happier when they were in nature of any kind compared with an urban environment, even after controlling for things like the day of the week or the weather. But marine and coastal areas were the happiest locations "by some distance", the researchers wrote.

Coastal areas came out about 6 points higher on a 100-point happiness scale than urban ones, equivalent to the difference between attending an exhibition and doing housework, the researchers said. Other types of nature, including mountains, heathland and even freshwater, scored much lower, with a happiness boost of around 2 or 3 points compared with urban areas.

The benefits don't stop with the seaside, either. In the past few years, more projects have looked at a range of blue spaces. One of these is the BlueHealth project, from a consortium of researchers across Europe, including White. The team found that when pitted against green spaces, such as forests and parks, blue spaces scored better for our physical and mental well-being. The best scenario of all, according to their results, is living somewhere where they meet.

White points out that when it comes to well-being, the effects of nature are a drop in the ocean compared with big-ticket factors such as employment, marital satisfaction or the ability to make sure your children are happy. Even so, his research has found that living near blue spaces can buffer against some of the mental-health inequalities driven by socio-economic differences. Past research on green spaces ›

Six tips for making the most of nature

TAKE YOUR TIME The health benefits of being in nature kick in after about 2 hours a week, according to a study of almost 20,000 people. Longer than that is better still, up to a total of around 5 hours, after which the gains plateau.

MAKE IT COUNT It doesn't matter whether time in wild spaces is taken in one go or broken up into little chunks during the week. One study found that individual chunks should be at least 10 minutes if you do decide to spread it out over several days.

continued on page 41

Doing it for the kids

Every parent or guardian of small children will have experienced the desperate urge to get out of the house, and the magical restorative effect of even a short trip to the local park. There is probably more going on here than just letting off steam.

The benefits for kids of getting into nature are huge, ranging from better academic performance to improved mood and focus, and helping with attention deficit hyperactivity disorder. Childhood experience of nature can also boost environmentalism in adulthood. And having access to urban green spaces can play a role in children's social networks and friendships, even promoting social inclusion across cultures.

The seaside works wonders too. Mathew White at the University of Exeter, UK, has studied children who had been expelled from school or were at risk of expulsion because of behavioural issues, and who had been enrolled on a surfing programme. He found that as well as getting fitter, the kids ended up with more positive attitudes towards school and friendships. They also had a more positive body image, which is especially important because, in the early teenage years, this is one of the strongest predictors of well-being.

"BLUE SPACES OFTEN HAVE PATTERNS OF CHANGE THAT YOU DON'T GET WITH GREEN SPACES"

has sometimes been accused of focusing too narrowly on the middle classes, but two large studies have now shown that people with low incomes who live by the sea are mentally and physically healthier than would be expected given their greater exposure to major drivers of decreased well-being, such as unemployment.

It makes a good deal of sense that we find being outdoors so revitalising if we consider our deep past. In the early 1980s, biologist E. O. Wilson put forward his biophilia hypothesis, which says our brains are wired to seek out a connection to nature because of the environment we evolved in – which is very different to the ones most of us live in today.

Another idea that purports to explain our love of the wild is known as attention restoration theory. In a nutshell, it says that our ability to concentrate is restored by time in nature. Attention can be divided into two types: involuntary, in which our attention is captured by intriguing or important stimuli (an intimate conversation between a couple sitting at a table behind you in a cafe, for instance), and directed or voluntary attention, where you actively focus on something (the book you were trying to read before you started eavesdropping). The latter requires what psychologists call top-down control, which means that our thoughts are regulating our actions. In contrast, bottom-up thinking is where sensory information is influencing our thoughts.

During directed attention, we need to suppress distractions, which is mentally exhausting. This is where nature comes in. It is bursting with subtle, eye-catching stimuli, which trigger the bottom-up, involuntary kind of attention that gives the thinking mind a break. If you have ever felt revived after watching a glorious sunset or gazing at the trees swaying in the breeze, it might be because these sights have given the top-down mental processes some time off, allowing them to replenish.

This idea also helps explain why blue spaces seem to be even better for us than other types

Places where water meets green space can be the most restorative of all to spend time in

LEVENTE BODO/GETTY IMAGES

New Scientist audio
You can now listen to many articles – look for the headphones icon in our app **newscientist.com/app**

of nature. Blue spaces, especially the coast, often have patterns of change that you don't get with green spaces. The tide ebbs and flows, the waves lap at the shore, the sun glints on the horizon. As well as this movement, there are changes in sound, and even light, that you don't experience in a park or forest. There is a soothing energy to these environmental shifts and they generate what scientists call soft fascination, diverting our attention away from more specific thoughts – possibly even the negative ruminations associated with depression, says White.

Studies also find that blue spaces lead to certain behaviours that don't or can't take place in green spaces: playing in the sand, swimming, paddling and so on. Children often say that their parents play and engage with them more when they go to the seaside (see "Doing it for the kids", page 40). Regardless of whether such a visit is with family or friends, these kinds of activities seem to build strong, positive social experiences, and this quality time is, in turn, more beneficial for mood and well-being. White and his colleagues have been studying whether exposure to blue spaces in childhood has an effect on mental health as an adult, with their research soon to be published.

Another possible, if more controversial, explanation for the benefits of blue spaces goes back much deeper into our evolutionary past. Most evolutionary biologists think that humans made their departure from other apes on the evolutionary tree when they were forced out of the forest into the savannah. But in 1960, biologist Alister Hardy argued instead that our human ancestors moved from the forest to the shore, becoming adapted to an aquatic habitat. This aquatic ape hypothesis can potentially explain all manner of features, from our unusually good swimming ability to our largely hairless bodies and even bipedalism – the need to keep our heads above the water would have been a pretty strong driver for walking on two legs.

This hypothesis remains highly contentious. But even so, says White, there is plenty of evidence that our ancestors spent time in and around water. Some of the earliest human settlements were also packed full of discarded seashells, suggesting our ancestors had a high-protein diet that may have helped brain development. This doesn't necessarily translate into a propensity for beach holidays, but we certainly have a deep-rooted evolutionary link to water.

If you are lucky enough to live near the water, or are heading there for a well-earned break, there are ways to maximise its potential benefits (see "Six tips for making the most of nature", page 39). White and his colleagues' research has shown that the strongest predictor of good mental health wasn't proximity to or length of time spent in nature, but people's psychological connectedness to it. So rather than pina coladas on a lounger, you might want to take steps to immerse yourself in the natural world, by taking photographs, say, or bringing binoculars for a spot of birdwatching or even going rock pooling (see page 48).

A virtual stroll

If you are stuck in the city, there are still ways you can reap the benefits of blue spaces. Studies have found that simply looking at pictures of nature or watching natural history documentaries can emulate some of the effects, increasing positivity and beating boredom. Virtual reality has also been shown to be effective at mimicking the healing power of nature, possibly because it triggers that sense of connection. One study found that people who took a VR stroll by the beach while they were having a tooth extraction felt less pain, anxiety and stress, and also felt much happier about returning to the dentist later than those who took a virtual walk around a town or had no VR experience.

With all the attention being paid to making our urban spaces greener, we would do well to think about making them bluer too. And while some doctors prescribe time in nature, perhaps they should channel Victorian doctors and issue "blue prescriptions" as well. For those of us who already relish time spent waterside, you now have a science-approved reason to log off, head to the shore and enjoy the brain benefits that come flooding in. ■

continued from page 39

UNSPLASH/HARRY HOLDER

MAKE A CONNECTION The advantages of being outdoors are particularly strong if you feel connected to nature (see main story). So find ways to engage with it, whether that is by gardening, photographing the changing seasons or spotting birds and wildlife.

WRAP UP WARM Studies show that the mental health benefits apply not just in the summer, but in winter too, when many of us need it most. So keep that connection going all year.

DON'T FORCE IT Research finds that people experiencing depression and anxiety feel better when they spend time in nature – but it has to be their choice. When these people felt social pressure to visit nature, they were less happy and more anxious about the outing. This means nature "prescriptions" that doctors in several countries dole out can sometimes backfire. So engage in nature in ways that suit you and avoid pressuring others into it.

QUALITY OVER QUANTITY The specific qualities of green space seem to be more important than how big the space is. Two qualities in particular have been shown to reduce stress: spaces that act as a safe refuge – for instance, spaces enclosed by vegetation – and those that really feel like nature. Try seeking out these kinds of places.

Catherine de Lange is magazine editor at *New Scientist*. This is an edited extract from her book *Brain Power: Everything you need to know for a healthy, happy brain*

Bees vs wasps

Bees get all the good PR compared with wasps, but how do their talents really measure up? **Chris Simms** stages the ultimate insect showdown

L:MYN/CLAY BOLT/NATUREPL; R:STEPHEN DALTON/NATUREPL

IT IS a beautiful, sunny day. The smell of a barbecue is in the air and a bee is bumbling from flower to flower. Everything feels perfect. Then a wasp appears, stirring up rather different feelings: fear, loathing, anger.

Our widespread dislike of wasps – and love of bees – goes back a long way. "Hornets and wasps… are devoid of the extraordinary features which characterise bees," wrote Aristotle more than 2000 years ago. Was he right, or is there more to wasps than most people think?

It is hard to fairly compare different animals, but we enjoy a challenge, so here we pit the talents of bees against those of wasps in eight categories, from cognitive skills to stings, architecture to navigation. Which of these insects should we be buzzing about?

Communication

"Most social insects communicate with a vocabulary of chemicals and vibrations," says Fred Dyer at Michigan State University. This includes bees and wasps.

Honeybees use their abdomens to drum up vibrations to create a "get to work" signal. Wasps also engage in gastral drumming, banging their abdomens against the walls of the nest when there is food nearby.

Bees and wasps emit hisses, buzzes and chirps, and wasp larvae make a popping sound to alert adults that they need food.

On the chemical front, individual social bees and wasps release substances to communicate and provoke responses, such as recruiting others to join them in getting food or inciting them to defend their home. Queen honeybees produce a chemical mix called the "queen signal" that physiologically alters the development of other bees, suppressing reproduction and keeping all the insects working together.

But nothing rivals the honeybee dance language. The waggle dance is incredible, says Seirian Sumner at University College London, author of *Endless Forms: The secret world of wasps*. The insects move in a figure of eight to recruit other bees and indicate in what direction something is and how far away it is.

Wasps just don't have that level of communication, because their prey moves quickly and so there is often little point in going back to recruit others, says Sumner.

The waggle helps the bees win this round.
Bees 1 – 0 Wasps

Cognition

Despite having a brain the size of a poppy seed, bees have a basic grasp of numbers and can understand the concept of zero, carry out addition and subtraction and solve a complex navigation conundrum known as the travelling salesperson problem. Some bees demonstrate a basic level of metacognition – thinking about thinking – by assessing their performance on a task and avoiding it next time if it is too difficult.

Honeybees can even distinguish between human faces and remember them for at least two days. There is also evidence of simple tool-use in bumblebees, says Lars Chittka at Queen Mary University of London, who was part of a team that has shown that these insects will pull a string to get a reward. (See our review of Chittka's latest book on page 34 for more on the inner lives of bees.)

Can wasps touch that? Many more studies have been carried out on bees than wasps, so it is hard to tell for sure. But given that their prey (other insects and spiders) are hard to catch, while bees just navigate between stationary flowers, it is likely that the cognitive abilities of wasps are at least equal to those of bees, says Sumner.

We know that wasps are capable of a type of logical reasoning called transitive inference. Elizabeth Tibbetts at the University of Michigan and her colleagues have revealed that *Polistes* paper wasps can grasp that if A is greater than B, and B is greater than C, then A is greater than C. "These wasps are the only non-vertebrate shown to do it so far," says Tibbetts. They can also recognise and remember the faces of other hive-mates.

"Bees and wasps are both masters of their craft," says Andrew Barron at Macquarie University in Sydney, Australia. "Foraging is hard. You have to continuously solve an optimisation test and bring back more than you use."

Both show great smarts for such small creatures: it's a draw.
Bees 2 – 1 Wasps

Building skills

"Architecture is important for both bees and wasps," says Chittka. Both have mastered the art of making hexagonal cells in which to lay their eggs. "Hexagonal honeycomb doesn't just have beautiful symmetry, it is also mathematically optimal," he says. Square chambers leave wasted space in the corners and round ones have gaps between them.

When honeybees make their cells, they secrete wax from their own bodies, and leave a space between different sheets of honeycomb that is exactly two bees wide, so individuals can pass each other.

Yet wasps are more efficient builders. "Wasps use antennae to set the size of the cell, and the first one they build is a hexagon," says Sumner. "In bees, the first is a circle and then the ones built around become hexagonal."

Wasps use different building materials, too. They gather water and wood supplies and make paper to create their cells. And they use different types of wood for specific jobs, choosing rotting wood, preserved dead wood or fresh wood as necessary, says Sumner. They produce a material that is so strong a human can't bend it easily, yet is incredibly light and capable of holding the heavy brood. Wasps also build an envelope around the nest, enlarging it as the nest inside grows. Social wasps' nests, including those of hornets – which are a type of wasp – can also come in extraordinary shapes, ranging from balls to dresses or even tennis rackets, says Sumner.

Wasps have this one nailed.
Bees 2 – 2 Wasps

Usefulness (to us)

It is hard to overstate the usefulness of bees. Honey-making is just the start. The global honey market was valued at about $8.5 billion in 2021, and beeswax pops another $500 million on top of that. But the biggest economic contribution of bees is in pollinating flowers, thought to improve the global crop output by hundreds of billions of dollars every year.

What about wasps? Each species of fig tree (*Ficus*) has its own wasp species to pollinate its flowers, enabling a global market in figs worth some $500 million a year. There are other wasps that pollinate, including male wasps lured to orchids because the plants grow flowers that look and smell like a female wasp, and the aptly named pollen wasps, which collect pollen to feed their brood. Still, the contribution of wasps is small compared with that of bees.

The big value of wasps to us lies in their pest-control services, says Sumner. Wasps kill and eat woodlice, spiders, caterpillars, aphids and flies. Sumner calculates that *Vespula* wasps are likely to be removing more than 23,000 arthropods per hectare per year, which goes a long way to protecting your fruit and veg.

Some wasps can also help against invasive species, says Dyer. For instance, in the US, parasitic wasps have been released to control the invasive emerald ash borer beetle, which is damaging valuable timber supplies by destroying ash trees.

Pollination services make it a win for the bees.
Bees 3 – 2 Wasps

›

Bees at work, visiting a flower and executing a waggle dance

ANTON PETRUS/GETTY IMAGES

KIM TAYLOR/NATUREPL

BIOSPHOTO/ALAMY

KIM TAYLOR/NATUREPL

A hornet (a type of wasp) killing a bee, and a hornet nest

Cunning

Bees might look furry and cute, but honeybee queens begin life by murdering their sisters, says Chittka. Then there are tropical stingless bees in the *Lestrimelitta* genus that specialise in kleptoparasitism: they find nests of honey-making bees, kill or evict all the residents and steal their food. That's not to mention cuckoo bees, which will go to an existing colony, kill the resident queen and get the workers to raise their own young.

Wasps also exploit the work of others. Common wasps raid honeybee hives to steal honey, especially towards the end of summer. Asian giant hornets kill and decapitate a honeybee nest's guard bees, murder all the residents and take the honey, pupae and larvae to feed their own young – unless the bees can defend themselves by forming a bee ball, surrounding any hornets in huge numbers and overheating them until they die.

But all these are small fry when compared with the dementor wasp, *Ampulex dementor*. These puppetmasters inject venom into cockroaches, blocking neurotransmitter receptors, which stops the roaches from controlling their own movement. The wasps then lead their zombified prey by the antennae to their nests.

Charles Darwin was so affected by the antics of *Ichneumon* wasps – whose larvae hatch out of eggs laid on caterpillars and consume the living host from the inside before bursting out of them to pupate – that it made him question the existence of a beneficent and omnipotent god.

Wasps steal this round.
Bees 3 – 3 Wasps

Navigation skills

Some of us need a map or an app to find even the most prominent of landmarks, but bees can gauge distance, work out where something is in relation to the sun and use landmarks to find their way, even to somewhere several kilometres away. For an insect just a centimetre or so long, this is an impressive feat.

Less is known about these talents in wasps. In the 1930s, it was discovered that a type of wasp called the European bee wolf (*Philanthus triangulum*) uses landmarks near its nest, such as pine cones, to find its way home, and now we know that other species of wasp can do this too.

Most navigational studies are done on bees, though, because they are easier to work with and less hassle to keep in the lab, says Chittka. But he has anecdotal evidence of wasps' sense of direction. One of his team was studying how a bee navigated a maze when a wasp flew into the experimental set-up, so they decided to see how the wasp did. It turned out that the wasp was better at navigating the maze. Unfortunately, the experiment ended in tragedy when the wasp killed the bee.

Given the lack of data, another draw.
Bees 4 – 4 Wasps

Biodiversity

Wasps and bees have a close relationship. "Bees are a vegetarian group within the wasps clade," says Dyer. About 120 million years ago, when flowering plants were diversifying, bees arose from wasps. There are now about 100,000 species of wasp compared with some 22,000 species of bee, says Sumner.

Wasps are the clear winners here.
Bees 4 – 5 Wasps

Stings

Most people will be stung by a wasp or a bee during their lifetime, but given that many of us can't tell the difference between the two insects, reports of which caused the sting can be unreliable. This is why medical data relating to stings generally lump bees, wasps and other insects together.

For most people, a single sting will cause temporary localised pain, swelling and redness, but about 5 per cent of people will have a systemic allergic reaction, and about 32 per cent of beekeepers will, as they can become hypersensitive after receiving repeated stings.

The venom of both wasps and bees contains chemicals such as phospholipase A, an enzyme that destroys cells and is also an allergen; hyaluronidase, which helps break down carbohydrates so the venom can get through tissues; and pheromones to alert other wasps or bees.

Bee venom also includes melittin, which is a peptide that kills cells and stimulates inflammation, and the neurotoxin apamin. Wasp venom contains wasp kinin, which affects inflammatory responses; phospholipase B, which can immobilise prey; and acetylcholine, which stimulates pain nerves.

Female honeybees have a barbed stinging apparatus that can inject between 50 and 140 micrograms of venom for up to a minute. However, they can't sting again, whereas wasps can sting many times, injecting around 3 micrograms of venom each time. Some argue that a bee is less likely to sting you unless it is in dire need, because its serrated sting will stick in an animal and rip out the bee's organs, dooming it to die. "Wasps' threshold for stinging may be lower, but we don't know," says Barron.

Both stings are unpleasant, so it's another draw. Which means it might be time to give wasps a little more love.

FINAL SCORE
Bees 5 – 6 Wasps

Chris Simms is an assistant news editor at *New Scientist*

A knotty problem

Mathematicians are unpicking the question of how many knots exist. As they do, they are finding ways to solve other seemingly impossible problems, reports **Larissa Fedunik**

IT USED to be one of the most frustrating part of any journey on public transport. You squeeze your way past the other bodies, sit down and fish your earphones out of your pocket. You didn't bother to wind up the wires into a neat loop the last time you used them, and so – sigh – you now need to spend the next 5 minutes untangling this knot. Thank goodness for the invention of wireless earbuds.

Knots aren't just an everyday annoyance, though. They are also a source of endless inspiration for researchers. Take mathematician Benjamin Burton, who is fascinated by one simple question: how many knots are there? "There is something tantalising about problems that you can describe to a 10-year-old, but that mathematicians have not yet solved," he says.

Taking a census of knots is one of those problems that ought to be impossible to solve because of its complexity. There are so many ways the strings can be crossed and looped that even the fastest computer could never catalogue them all. Yet Burton has been giving it a shot, and along the way he is showing that, with a few clever computational tricks, many maths problems that seem insurmountable might not be.

Knots and science have been, ahem, entangled for quite a while. In the dying decades of the 19th century, scientists were grappling with how to understand atoms. One hypothesis saw them as little vortices of fluid that became stable when knotted. Lord Kelvin, who went on to become the president of the UK's Royal Society, was the first to suggest that each chemical element corresponded to a different type of knot.

The idea was abandoned after the discovery of the electron, but at the time it seemed vital to understand knots. Physicist Peter Guthrie Tait was the first to make a stab at creating a comprehensive list of them. Cards on the table: there are an infinite number of possible knots, because you can keep on adding extra knotty flourishes forever. The question mathematicians are interested in is more subtle. A defining feature of a knot is its crossing number, the number of times the strings cross. The question is, for a given number of crossings, how many different knots are possible? In 1885, Tait, working with mathematician Thomas Kirkman, considered all the knots with up to and including 10 crossings. Drawing them all by hand, he tabulated 364 configurations.

Try to go further and things quickly get a lot more difficult. As you allow more crossings, the number of possible knots rapidly increases. The last ›

SPENCER WILSON

“Imagine tying a knot in a piece of spaghetti, then melding the free ends”

major extension to the knot tables was published in 1998. Mathematicians Jim Hoste, Morwen Thistlethwaite and Jeff Weeks recorded all the knots up to and including 16 crossings – all 1.7 million of them.

Going beyond this has, until recently, been unfeasible. To see why, we need to know a bit more about how mathematicians think about knots (see “When is a knot not a knot?”, page 47). Unlike real-world knots that are often pieces of string with loose ends, mathematical knots are closed. Imagine tying a knot in a piece of spaghetti, then melding the free ends.

Stretch, twist, bend

Mathematicians treat knots according to the rules of topology, a branch of geometry. These say that a knot remains fundamentally the same if you stretch, twist or bend the strands – but making cuts or new joins is a no-no. This leads to the concept of a prime knot, a knot that can’t be mathematically broken down into two or more simpler knots.

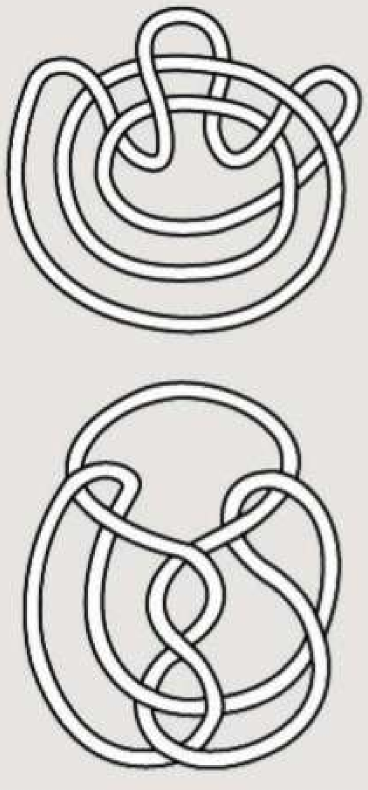
The job of tabulating knots, then, boils down to comparing elaborate tangles to see if they are really the same prime knot. Don’t underestimate how tricky this can be. For 75 years, two knots with 10 crossings were listed separately in tables. But in 1973, Kenneth Perko, a New York lawyer who had studied maths, realised that if you take the mirror image of one, you can manipulate it to become equivalent to the other. The knots are known as the “Perko pair” (see “Tricky tangles”, right).

When dealing with millions of knots, the job of identifying doppelgangers becomes so time-consuming that even the fastest supercomputers shouldn’t be theoretically capable of it in a reasonable amount of time. Still, in 2019, Burton, who is based at the University of Queensland in Australia, decided the time was ripe to take a punt.

He knew there is a difference between a knot-sorting algorithm in the abstract and how that algorithm is implemented in computer code. The art of bridging this gap is known as algorithm engineering and Burton thought that with the right tricks, the problem wouldn’t be as hard as it seemed. “Part of what motivated me was creating a showpiece to see if the tools were good enough,” he says.

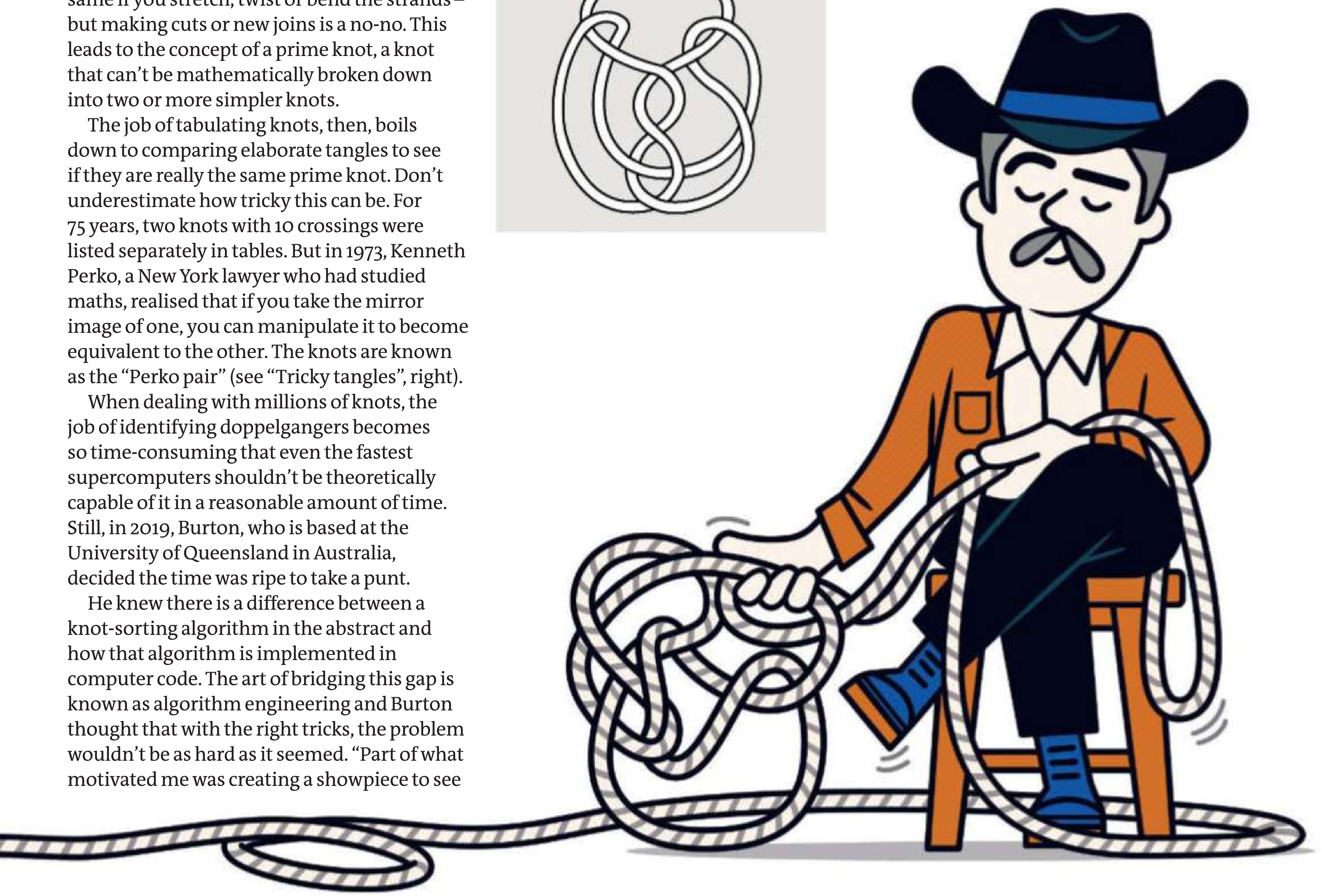
Tricky tangles

Sometimes two knots that look completely different can be twisted and pulled into equivalent arrangements. These two knots, known as the Perko pair, were thought to be different for decades – until a part-time mathematician discovered otherwise



He began by setting a computer the task of dreaming up all the possible ways that strings can be knotted with up to and including 19 crossings. This is a comparatively simple task and the computer spat out 21 billion knot candidates after just a few days.

The job was then to check each knot was prime and distinct. This involves storing a full topological description of the knots in a computer’s working memory or RAM. A data set of 21 billion knots would require more than 1 terabyte of RAM to store, and computers with that amount are rare. To get around this, Burton made use of a software package he has



developed called Regina. It can convert knots into "knot signatures", strings of letters that capture each tangle's defining topological properties. The signatures can be stored far more economically than a knot description. Plus, knots that are tangled differently but are really equivalent have the same signature, making it easy to weed out duplicates. Burton managed to whittle down the candidate knots to about 7 billion in a day.

This method wasn't powerful enough to identify every last duplicate, however. Burton's next tactic involved calculating what is known as a knot invariant for each candidate knot. Invariants are mathematical objects that capture the essence of a knot – if two knots have different invariants, they are different knots. Invariants are more powerful than signatures, but they are harder to compute: it would have taken Burton's computer more than a year to calculate these for all the remaining knots. By sorting them into groups and running them on parallel supercomputers, he got through them in days. The pool was down to 370 million.

Burton also had to grapple with non-hyperbolic knots, an especially challenging category. But after several more rounds of sorting, the supposedly impossible became possible. Burton's census extended the knot tables to cover everything up to and including 19 crossings. The final tally: 352,152,252 knots.

Ian Agol at the University of California, Berkeley, says he is impressed with the calculations. "It will likely be useful to mathematicians searching for knots with specific properties, or who have a knot that they would like to identify," he says.

He and other mathematicians think that Burton's work is also an impressive example of algorithm engineering. "This is a growing trend in pure mathematics, where computational methods are being used in more creative ways," says Hans Boden at McMaster University in Ontario, Canada.

Lorries and cameras

There are plenty of practical problems where algorithm engineering is used to find efficient solutions to hard problems. Some of the most important are in logistics, where optimised routing can save time and huge sums of money. Others include working out how to cover a space with CCTV cameras. In many cases, a perfect solution is impossible to obtain in a reasonable time frame.

This is also the case when it comes to mapping complex evolutionary histories, particularly for plants and bacteria. Algorithms are used to link DNA data in phylogenetic trees, graphs that group closely related species more closely than distantly related ones. However, sometimes genes don't pass down from parent to offspring, but rather through what is known as horizontal gene transfer from one species to another. Algorithms designed to map these transfers can be very slow.

One algorithm engineering hack to get around this involves parametrising data inputs to make them smaller. For instance, if you fix the number of potential mutations you are considering, the problem can be solved efficiently. Recently, Edwin Jacox, now at the University of California, Santa Cruz, and his colleagues applied this method to cyanobacteria phylogenetic trees. Cyanobacteria played a major role in Earth's changing biosphere more than 2 billion years ago. The researchers developed a parametrised algorithm that rebuilds the cyanobacteria phylogenetic trees in just 15 seconds.

Whether it is reconstructing evolutionary trees or listing knots, it is clear than the toughest computing problems can be made tractable. "With algorithm engineering and heuristics, things that are slow in practice turn out to be remarkably, surprisingly fast," says Burton. It means that even the trickiest problems don't have to leave us in an inescapable tangle. ▮

WHEN IS A KNOT NOT A KNOT?

Here is a problem that needs unpicking: if you pull at a messy tangle of wires, how do you know if it will just get more tangled or come apart into a simple loop? This is a problem mathematicans call "unknot recognition" and it is one we might soon solve. Unknot recognition fascinates mathematicians and computer scientists alike because it is part of the famous "P vs NP" question.

To see how it works, take the classic travelling salesperson problem, where we must work out the shortest route for a salesperson to visit a number of cities. If an algorithm designed to solve this problem doesn't get exponentially harder as more cities are included, it is said to be "P". This means it is solvable in reasonable – or polynomial, in maths speak – amounts of time. Once you have an answer, you need to check it is correct. If it is easy to check your answer, the problem is classed as "NP". The big question for mathematicians is whether all NP problems are also P. This is one of the Millennium Prize Problems – answer it conclusively and you will win $1 million.

Unknot recognition dwells in the twilight zone of P vs NP. We already know that this problem is definitely "NP", or easy to check. If your algorithm can produce an unknotted loop, you can immediately see it has worked. Mathematicians also think it is likely to be P, and we are tantalisingly close to proving it.

In 2014, Benjamin Burton at the University of Queensland in Australia developed an unknotting algorithm that, in practice, solves in polynomial time. His algorithm has held up "for every knot we've thrown at it so far", he says. More recently, Marc Lackenby at the University of Oxford developed an unknot recognition algorithm that is "quasi-P" (which, in maths parlance, means "almost there"). It is unlikely to be converted into executable computer code because it is so complicated, but Lackenby is confident that a simplified version "is going to be genuinely practical".

Showing that unknot recognition is both P and NP won't solve the wider Millennium Prize Problem, though it could give us useful pointers. Still, it is an important milestone and mathematicians will be celebrating once we get there.

Larissa Fedunik is a writer based in Sydney, Australia

With a little knowledge, you can elevate this humble pastime to an experience that connects you deeply with nature, says **Joshua Howgego**

The grown-up guide to rock pooling

West Runton beach in Norfolk, UK, where *New Scientist* went searching for treasures

TOP MIDDLE ROW: ALEX MUSTARD/NATUREPL.COM ALL OTHER PHOTOS: DAVID STOCK

As I clamber out of the car for a day at the beach, it is – in typical British fashion – absolutely freezing. Most sensible people have stayed at home. But despite the conditions, I am in a joyous mood. I have come to West Runton, Norfolk, to do something I have loved ever since I was a child: go rock pooling.

Even better, I have persuaded one of the world's foremost experts on seashells to come along with me. Author Helen Scales trained as a marine biologist and has written two books on seashells. There isn't much about marine creatures she can't tell you.

We pull on windcheaters and woolly hats. But as we stride towards the water, I worry that we won't find anything interesting. How fascinating can life get on a cold and windy beach in England? As it turns out, I needn't have been concerned. Rock pools are just as beguiling in real life as they are in our collective imagination, and I am about to encounter an incredible range of underappreciated species.

What's more, you can too. If you look closely and arm yourself with a little knowledge, there is an awful lot to appreciate about the lives in this little-understood habitat.

As we walk towards the beach, we pass a sign encouraging us to be "respectful rockpoolers". Scales gives me a quick primer on what that means. Lift up rocks carefully and always put them back where they came from. Don't pull animals like snails off rocks – you could hurt them. For extra points, do a quick beach clean, picking up any litter you see, before leaving.

To be a successful rock pooler, you want to investigate not just the water, but the damp nooks and crannies between rocks. "That's when things start getting more interesting," says Scales. "Under the rocks and among the seaweed." I crouch down and begin looking.

Scales quickly finds our first animal. It looks like a tiny jelly sweet, the colour of a red-velvet cupcake, stuck to a dry rock. This beadlet anemone (*Actinia equina*) looks kind of small and forlorn to me, and I ask Scales if these animals are threatened. "No, they're fine," she says. "They're pretty hardy, they're not a species that we're particularly worried about in terms of climate change." In the next rock pool along, I see four more. In the water, they have a delicate fringe of tentacles and stinging cells they use to catch surprisingly large animals like crabs or fish. We watch them for a while. I put my little finger next to them in the cold water and feel one of the anemones gently suck at it.

While beadlet anemones are doing fine, climate change is having a big effect on intertidal environments. Heatwaves are one of the most striking problems. In July 2021, searing temperatures struck Canada and millions of shellfish were cooked in their shells at low tide as temperatures reached 49°C in some places. In addition, the gradual increase in average temperature is causing patterns of habitation to shift. In the Shetland Islands, north of mainland Scotland, the mix of species now includes many more warmer-water animals. These are the kinds of species that lived on the shores of mainland Scotland 40 years ago, says Scales.

Worms and thunderstones

I am beginning to get my eye in. In the next rock pool, I spot a strange structure that looks almost like a tiny, filamentous plant, the colour of sand. This is the work of the sand mason worm (*Lanice conchilega*), Scales explains, which sticks together sand and shell chippings into a tube that it lives in. The tubes are common, but you rarely see these worms, which live under the sand or mud, even though they can reach 30 centimetres in length and there can be thousands per square metre.

Next, we find our first shell – well, sort of. To me, it looks like a small, conical stone. When Victorian naturalists first found these, they called them thunderstones, thinking they were created by bolts of lightning. But Scales explains that it is a belemnite, the fossilised internal shell of a squid-like animal that went extinct about 65 million years ago. Belemnites are robust and fairly common on UK shores, often surviving while others get smashed by the waves. Fossil deposits sometimes have lots of them lined up in the same direction, which can tell us the direction of prevailing ancient currents. We can also analyse the chemical isotopes stored in their shells to reconstruct trends in temperature for the distant past.

Now we are really getting into it, sticking our arms into the pools and upturning rocks. We start to find a lot of molluscs. There are top shells, which are small and roughly symmetrical in shape, like a cone. There are common winkles (*Littorina littorea*). And there are dog whelks (*Nucella lapillus*), which seem to be doing exceptionally well here. "In the mollusc world, these are a top predator," says Scales. They hunt other snails, secreting acid to weaken their shells and then using their tongue-like radula to punch through them. "They drill a hole and slurp out the insides." We even find a crop of pink and bright-yellow dog whelk eggs under one rock.

Scales gives me a helpful rule of thumb to distinguish between all the shells. Look at the shape of the opening on their bottom. If it is

›

The shells that got away

Here are impressive shells that we didn't find on the east coast of the UK, in Norfolk, but that you might be lucky enough to spot elsewhere.

CONCH – the common name for a number of sea snails found in the tropics. They have elaborately shaped shells that rise to a cone at one end. In some communities, holes are made in conch shells to turn them into horns.

PAINTED TOP SHELL – there are many types of top shell to find in British waters and elsewhere. One attractive kind is the painted top shell, which can be found in south-west England, for instance. Its cream spirals are interlaced with a vivid light and dark-pink strand.

GEODUCK – pronounced "gooey-duck", this is a species of giant clam native to the North Pacific Ocean. The shells are around 15 centimetres long and look unremarkable. But because this species buries itself deep in the seabed, it has a huge, fleshy siphon, the organ through which it "breathes" water, that can be 1 metre long.

GUMBOOT CHITON – found on the northern shores of the Pacific Ocean, this chiton can reach nearly 40 centimetres in length.

Shells with elaborate shapes, like this conch, can be found in the tropics

PINOPIC/GETTY IMAGES

New Scientist video
For more reasons to go rock pooling, watch our accompanying video **youtube.com/newscientist**

Helen and Joshua found plenty of shells, including common winkles (bottom middle), and a greater pipefish (bottom right)

DAVID STOCK

more or less round, you have a herbivore (like a winkle or top shell). If it is shaped more like a comma, that is probably a predator. The little notch in the shell (the pointy end of the comma, if you like) is a space through which the predator sticks its "nose" – more properly known as its siphon – to "sniff" for prey.

Shells can also reveal the age of the animal that inhabits them. Molluscs, such as snails, have the same shell all their lives and build it by secreting calcium carbonate, which they take in from seawater. There are lines in the shells that can be read in a way that is akin to tree rings. By counting them, you can get a rough idea of how many years old the inhabitant was.

To do this properly, you cut a slice of the shell and examine it under a microscope. About a decade ago, Paul Butler, then at Bangor University in the UK, and his colleagues did this with a shell from a species of clam called the ocean quahog (*Arctica islandica*). They found that one clam, nicknamed "Ming", had reached the ripe old age of 507, making it the oldest animal known to science, excepting some colonial animals like corals.

The next thing we find is an animal I have never heard of. I turn over a rock and Scales points to what looks like a tiny, white flake about half the size of a fingernail. Peering closer, it looks much like a woodlouse. "I do like a nice chiton," says Scales. "It's super cute."

> "Woodlice-like animals called chitons have hundreds of 'eyes' in their shells"

Chitons are strange animals. The bodies of these molluscs are covered in a shell made of six articulated segments. If they are dislodged from a rock, they can curl up into a ball. They have also been shown to be capable of finding their way back to the same spot on the same rock at each low tide. They have "teeth" on their undersides made of a magnetic mineral called magnetite, which might be able to sense Earth's magnetic field and perhaps help them navigate.

As if that wasn't enough, scientists confirmed in 2015 that chitons have hundreds of "eyes" called aesthetes in their shell. These are made of aragonite, the same material as the rest of the shell, but here it is transparent. Studies have shown that they can focus light on a retina containing about 100 light-sensitive cells and so form simple images. "With eyes dotted all over their back, they have a good field of vision, even if the images are grainy," says Scales.

We decide to make our way up the beach, further towards the high-tide line. We come across some bryozoans, a class of tiny animals, each only half a millimetre or so long, that cluster in colonies of all shapes and sizes. Here, colonies have formed branching structures that seem very much like seaweed. But looking closely at the surface, we find pinprick-like pores, where each individual animal, called a zooid, lives. If you want to work out if a find is seaweed or bryozoans, look for those holes.

I am listening to some skylarks when Scales takes a sharp intake of breath and says: "Ah, no! Wow!" A pause. "I've never seen that before – this is amazing." I quickly walk over. She is crouching over the remains of a creature that looks like a giant seahorse or perhaps a strange species of snake. It is almost as long as my arm and incredibly beautiful. Its body is striped green and black, but it reflects daylight in all sorts of other colours, too. I have no idea what I am looking at, but Scales says it is a pipefish.

"It's a big one," she says. "I think it's a greater pipefish." Like seahorses, the males carry and care for the young. We think seahorses evolved from a pipefish ancestor about 45 million years ago. "Imagine this pipefish upright in the seagrass," says Scales, "its head bent over so it could see in front of it and its tail curled round the grass so it could hold on." Hey presto, you've got yourself a seahorse. Like seahorses, pipefish are quite poor swimmers because they only use a small dorsal fin for propulsion. This means they often live in the shallow waters that are easily affected by pollution, so they are threatened. It also means they are sometimes washed up onto the beach after storms.

By this point, I have lost all feeling in my fingers, but, boy, the cold has been worth it. As we are making our way off the beach, Scales talks about how we are bombarded with bad news and worries about the environment these days, what with the dual crises of climate change and biodiversity losses. It is right that we worry about those, she says, but it is also no bad thing to reconnect with nature. Having been astounded at the richness of life hiding out here among the rocks, I couldn't agree more. ▮

Helen Scales's children's book *What a Shell Can Tell* (Phaidon) is out now.

Joshua Howgego is a features editor at *New Scientist*

JUST LAUNCHED
All images now available on
Polished Aluminium up to 1.2 metres
wide. See website for details.

New Scientist Jobs

Time to bring your career to life

Sign up for the latest jobs,
courses and career advice

newscientistjobs.com

New Scientist Shop

NEW SCIENTIST TOTE BAG

Our reusable tote-style shopper bag is perfect for taking everything you need on the go. They are lightweight with double handles to make them strong for carrying all your essential items.

shop.newscientist.com/tote

worldwide shipping available

Puzzles
Try our crossword, quick quiz and logic puzzle p53

***Almost* the last word**
Could dinosaurs have developed human-like intelligence? p54

Tom Gauld for *New Scientist*
A cartoonist's take on the world p55

Feedback
Trolley trouble and where's the beef: the week in weird p56

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p56

Stargazing at home

Pinpointing Pluto

Track down a telescope and pray for dark skies, as a chance to see Pluto, our beloved dwarf planet, is coming up, says **Abigail Beall**

Abigail Beall is a feature editor at *New Scientist* and author of *The Art of Urban Astronomy* @abbybeall

What you need

A telescope
Dark skies
A star-finding app, like Stellarium

Stargazing at home appears every four weeks

Next week

Science of gardening

JUST last month, stargazers were treated to a planetary feast, with five planets visible to the naked eye, plus Uranus for those with binoculars, gracing our early morning skies. Now, not one to be left out, Pluto is making an appearance. But it won't be easy to see – you will require a telescope, dark skies and an eye for detail.

Pluto isn't an official planet – it was downgraded to the status of dwarf planet in 2006. It is now one of five dwarf planets recognised by the International Astronomical Union, another of which is Ceres, the only dwarf planet found in the asteroid belt, which appeared in our skies last November. But Pluto, with its icy heart, has captured the hearts of many. Particularly those, like me, who were taught about the planets before 2006 and still remember their order using a mnemonic that ends in a word beginning with "P" (My Very Early Morning Jam Sandwich Usually Never Pleases, was mine).

Planet or not, Pluto is small, only 1188 kilometres in radius, and extremely far away. Its distance from Earth varies, but currently it is around 5 billion kilometres from us, roughly 34 times our distance from the sun. This means it is impossible to see with the naked eye, or even with binoculars. Finding Pluto will require dark skies and a telescope that can see faint objects with magnitudes as small as 14.9.

ALLEXXANDAR/ALAMY

Even with this set-up, Pluto will be tricky to identify because it will look just like a star through the telescope. Unlike the other planets, which appear as circles, Pluto is so far away it looks like a single point of light – as stars do. The only way to be sure that what you have seen is Pluto is to look at the same spot the next evening, and if the light you think is Pluto has moved, you were right.

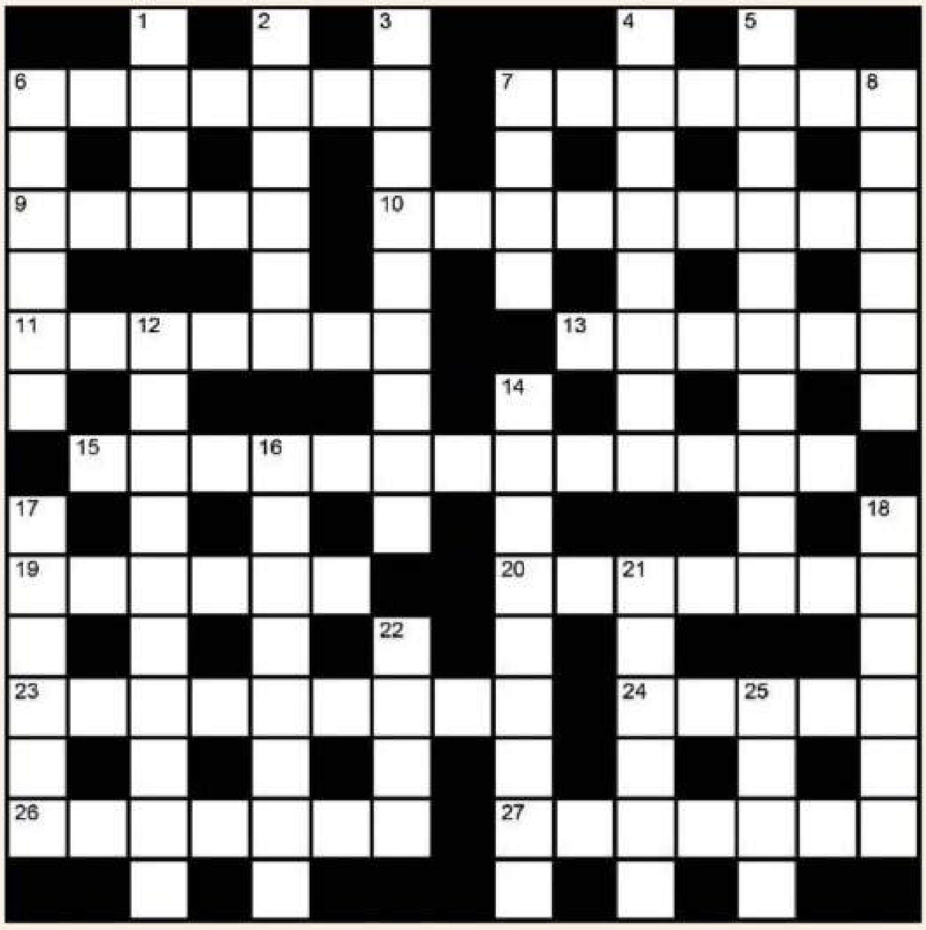
The good news is, Pluto is reaching opposition – meaning it will be on the opposite side of Earth to the sun – on 20 July. This is the best time to try to spot it, and it means it will be easiest to view at midnight local time, wherever you are in the world.

Some places will get a better view than others. In the UK, Pluto will only rise a few degrees above the horizon, making it harder to find. In the southern hemisphere, it will rise much higher, and skies will be darker because it is winter, making astronomers in the south better placed to find the dwarf planet this time.

Regardless of where you are in the world, Pluto will appear between the constellations of Sagittarius and Capricornus. Use a star-finding app such as Stellarium to check exactly where Pluto will appear, as viewed from your area. You could even print a series of star charts, zooming in from easily identifiable stars until you can precisely locate the dwarf planet in the sky. It will be much more difficult to see Pluto than it is to see the true planets, but it is worth a try – if for no other reason than to not leave Pluto out, again. ▮

These articles are posted each week at newscientist.com/maker

Quick crossword #112 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

6 Camera component (7)
7 1958 sci-fi film starring Steve McQueen (3,4)
9 Projection at the back of the soft palate (5)
10 Seabird that might be black-browed or wandering (9)
11 Inner organs of the chest and abdomen (7)
13 Yearly (6)
15 Upsurge of smoke, vapour and debris arising from a large explosion (8,5)
19 Stem bearing pedicellate flowers (6)
20 Toxic plant also called monkshood or wolfsbane (7)
23 1991 firefighter drama (9)
24 Unit based on the distance from the elbow to the middle finger (5)
26 Under the influence of a tranquilliser (7)
27 "___ is one thing, wisdom is another" – Thomas Love Peacock, 1861 (7)

DOWN

1 Large horned antelope of eastern and southern Africa (4)
2 C_2H_6 (6)
3 The Great Bear (4,5)
4 Powerful opioid drug (8)
5 Middle-altitude clouds (10)
6 Vitamin C deficiency (6)
7 Hollow cylinder (4)
8 Fine-grained igneous rock (6)
12 2011 sci-fi thriller starring Jake Gyllenhaal (6,4)
14 UK term for a type of cytopathologic examination (5,4)
16 Concentration of water vapour in air (8)
17 Antarctic mountain (6)
18 Pounding tool, used with a mortar (6)
21 Flowering plant that might be bird's-nest or lady's slipper (6)
22 0.9144 metres (4)
25 Microsoft search engine launched in 2009 (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #160

1 US astronomer Asaph Hall is best known for discovering moons around which planet?

2 Where in the human body would you find Haversian canals?

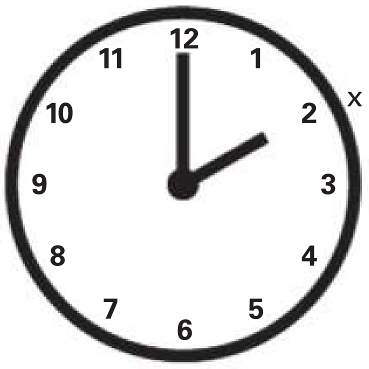
3 What is the atomic number of palladium?

4 In machine learning, what does GAN stand for?

5 Xanthophylls and carotenes are the two main classes of what?

Answers on page 55

Puzzle
set by Howard Williams
#176 Ant-i-clockwise



When the giant town-hall clock chimed 2 o'clock, an ant resting by the number 2 woke from its nap. Spotting that the minute hand was edging towards it, the ant started walking clockwise round the rim of the clock face. Thinking it had escaped the minute hand, it was shocked when it caught up with the hand again. At that point, the ant turned round and walked anticlockwise back round the rim, at the same constant speed as before, reaching the minute hand for a second time after a further 15 minutes. At this point, it decided to give up and take another nap.

At what time did the ant stop walking?

Solution next week

Smartosaurus

What are the chances that dinosaurs would have developed human-like abstract intelligence if they hadn't been wiped out?

Tim Lewis
Narberth, Pembrokeshire, UK
They have! Articles in *New Scientist* over the years refer to the intelligence of dinosaur descendants.

Birds such as the New Caledonian crow show sophisticated use of tools, as well as the ability to plan ahead. Magpies have demonstrated cunning and deception and many migratory birds have almost miraculous powers of navigation.

Gary Miller
Metamora, Michigan, US
To begin, it must be understood that there is no inevitability for human-like intelligence to evolve. The evolutionary process has no preplanned outcome.

Dinosaurs, had they survived (ancestral birds notwithstanding), wouldn't necessarily have evolved great intelligence, but if some did, it probably would be more bird-like than human-like owing to dinosaurs' closer ancestral relationship to birds.

> **"I predict that the odds of a different kind of animal ever evolving a human-like intelligence are highly unlikely"**

Certainly, some of today's modern birds are quite intelligent, but presumably they don't meet the questioner's qualified definition.

There are an estimated 7 million to 10 million animal species on our planet. If we allow that our form of intelligence is unique, then the odds that it evolved as it did were about 1 in 7 million to 10 million. These are rather long odds. I would predict that the odds of a different kind of animal, especially a dinosaur descendant, ever evolving a similar human-like intelligence are highly unlikely. In reality, the odds are probably incalculable considering the number of variables that would contribute to the same outcome.

Many animals have evolved remarkable intelligence, but intelligence isn't universal. While it appears to be a useful characteristic, it isn't always necessary for survival as evidenced by the existence of the many animal species that we don't consider intelligent.

DON MASON/GETTY IMAGES

Do parents' fingerprints determine how their children's turn out?

This week's new questions

Original print **What determines fingerprints? Is it a random process or is it something inherited from our parents?** ***Manyando Milupi***, *Muscat, Oman*

Pipe line **Aiming a hosepipe, intuition told me a 45-degree angle would maximise the distance travelled by the water, as it would for a projectile. But when I did this, the water actually went a shorter distance. Why?** ***Robert Morley***, *London, UK*

Buzz off

Why do insects like bees and flies buzz when flying? Does expending energy to make this sound help them?

Guy Cox,
Sydney, New South Wales, Australia
When birds or insects fly, they displace air with their wings – that is how it works. Maybe sometime at night you have disturbed an owl and heard the flap of its large wings. This sound is a frequency way below hearing it as a note, but the principle is the same.

Hummingbirds are the only birds small enough to produce an audible note with their wings.

Bees don't try to buzz, it is just the natural frequency of their wings.

Mike Follows.
Sutton Coldfield,
West Midlands, UK
The buzzing sound is usually caused by the displacement of air as insects flap their wings. Smaller wings can be moved faster, so smaller insects tend to buzz at a higher frequency. Producing even a loud sound doesn't expend much energy.

As well as being a consequence of flight, buzzing can also be used to communicate. Insects such as mosquitoes change the frequency of their buzz to attract a mate.

Some moths use sound to evade predatory bats. For example, as the hindwings of *Yponomeuta* moths flap and bend, ridges on their surface rub against the air to create ultrasonic clicks warning bats that they aren't very tasty.

Remarkably, buzzing is also responsible for pollination in 10 per cent of flowering plants. In a process called buzz pollination, also known as sonication, some solitary bees and bumblebees deliberately vibrate their flight muscles to match the resonant frequency of the anthers in the flowers they visit in order to dislodge the pollen. Some of this is consumed and some is inadvertently carried to the flowers they subsequently visit. Apparently, tomato plants can be buzz pollinated by touching the back of the flowers with an electric toothbrush and switching it on.

Mosquitoes fly and flirt at the same time. Male mosquitoes are smaller than females and buzz at a higher frequency (at about 600 hertz compared with around 400 Hz). When in close proximity, they try to match their buzzing frequency to signal to each other their potential as a mate. It appears that the female chooses a mate that is on her wavelength – literally.

Chris Daniel
Colwyn Bay, Conwy, UK
Flying insects buzz because their wings have to beat fast enough to generate lift, but this also produces a sound that we can hear, called the flight tone.

Insects can be identified by their

Want to send us a question or answer?
Email us at lastword@newscientist.com
Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

Tom Gauld
for New Scientist

WE'RE ALL IN FAVOUR OF REWILDING, JOAN. WE'RE JUST QUESTIONING WHETHER THE BEST PLACE TO BEGIN WAS THE STATIONERY CUPBOARD.

characteristic frequencies, and even within a species, the male and female are distinct from one another.

A honeybee's wings vibrate around 230 times a second, producing a frequency about three semitones below middle C. Other insects, many of which are flies, buzz at up to 2000 Hz, depending on their weight and the size of their wings. Mosquitoes, for example, flap their wings between 400 and 800 times per second, producing a higher pitch than bees or houseflies, but at a lower volume due to their smaller size. Hence they are often heard only in quiet rooms or when they get close to your head, attracted by your warmth and exhaled carbon dioxide.

Some insects buzz to communicate. Courting mosquitoes detect each other's wing-beat frequency through their antennae and the male will respond by modulating its higher frequency to match that of the female. If this means arriving at a wing-beat that is incompatible with flight, the two insects will instead converge on a shared harmonic.

> **"Male and female mosquitoes try to match their buzzing frequency, to signal to each other their potential as a mate"**

Placebo power

What is it exactly that provides the healing effect of a placebo treatment? (continued)

Peter Slessenger
Reading, Berkshire, UK
The placebo effect relies on the subject knowing that they are taking or doing something, and so some ceremony, however informal, is involved. This wasn't mentioned in previous answers to this question (21 May).

There are ceremonies for awarding credit, such as graduations, marriages and birthday parties, and for humiliation, such as court hearings. Each has a psychological effect, as does taking a tablet.

I know someone prescribed an SSRI antidepressant in case of stress, who, on experiencing a panic attack, took one tablet and immediately calmed down. As the drugs don't work that fast, he concluded what he actually needed was a placebo, as the ritual was having the required effect. Knowingly taking a placebo has been shown to reduce the need for medication in treating back pain or IBS.

However, placebos and rituals often have no medicinal effect. One of the most notorious examples is the USPHS Syphilis Study at Tuskegee, which failed to treat Black men for syphilis. What's more, the subjects weren't informed they were part of a study and they didn't give any informed consent to be part of such a trial. The experimenters wanted to discover how syphilis progressed when untreated, but they acted as if genuine treatments were being provided. ▮

Answers

Quick quiz #160
Answers

1 Mars – he discovered Deimos and Phobos
2 In bone, specifically in the outermost layer
3 46
4 Generative adversarial network
5 Carotenoids, a group of organic pigments

Cryptic crossword #87 *Answers*

ACROSS 7 Sacrum, **8** Teasel, **9** Limb, **10** Echidnas, **11** Neuston, **13** Anion, **15/21** Epsom salt, **17** Manakin, **20** Nuthatch, **22** Scores, **23** Marrow

DOWN 1 Canine, **2** Grub, **3** Emperor, **4** Itchy, **5** Gardenia, **6** Gelato, **12** Smothers, **14** Fathoms, **16** Pounce, **18** Igloos, **19** Stash, **21** Sort

#175 Wizard of odds
Solution

Jane gets Dorothree, Nicki is the Ten Man, Kasey is the Square Crow, Leah is the Cowardly Line and Megan gets the Wicked Witch.

Kasey can't be Dorothree, because that would make statement 1 a contradiction. If Jane isn't Dorothree, then based on statements 2 and 3, Leah would need to be the Square Crow and Nicki the Cowardly Line, but then number 5 presents a contradiction. So Jane must be Dorothree.

Then, based on 1 and 4, Nicki is the Ten Man and Kasey the Square Crow. That leaves Leah as the Cowardly Line (from statement 5) and, finally, Megan as the Wicked Witch.

Trolley trouble

It is the morning rush, the tram is full to bursting and Feedback wonders who to sacrifice for the greater good. Pulling an imaginary lever will prevent a crash and divert us onto a track with just one individual tied to it? Eminently reasonable.

This brand of thought experiment, first formulated in a 1967 philosophy paper by Philippa Foot, gets a video-game outing on developer Neal Agarwal's Absurd Trolley Problems website.

Following a tip from Motherboard, Feedback visited the site and rattled through some classic trolley problems, only to be transported to some very strange territory indeed. For example, "Oh no! A trolley is heading towards 5 lobsters. You can pull the lever to divert it to the other track, running over a cat instead. What do you do?" As if Feedback would harm so solitary and self-sufficient a beast!

Where's the beef?

It is as well we have something to distract us because we are jolly hangry this morning. This godless marriage between the words "hungry" and "angry" may be with us for a while, now that 64 people, mostly from Austria and Germany, have helped researchers put some numbers on the soaring levels of anger and irritability, and plummeting capacity for pleasure, occasioned by missing a meal.

The results, explored on *New Scientist*'s website (6 July), were solid enough (being hangry is, it seems, a "thing"). However, the study's second questionnaire included a section on eating styles and, "interestingly", discovered that only 23 per cent of respondents said they knew when they were full and then stopped eating. Feedback's conclusion: when visiting central Europe, bring extra sandwiches.

Right now, Feedback could eat a horse (just under 300 kilograms, of which 60 per cent is muscle). Or a fellow passenger.

Actually, scratch that: according to a paper in *Scientific Reports* by James Cole at the University of Brighton, UK, humans are only 38 per cent muscle and not that nutritious. So you have got to wonder (a) which dinner parties in Brighton to avoid and (b) why hominids in the Palaeolithic bothered eating each other in the first place. You would need to cannibalise three humans a day to feed a 25-strong tribe.

Twisteddoodles *for New Scientist*

AN ACT AT A MUSIC FESTIVAL
A SPEAKER AT A SCIENTIFIC CONFERENCE
AUDIENCE MEMBERS LISTENING OUT FOR THAT ONE SONG THEY ACTUALLY KNOW
AUDIENCE MEMBERS LISTENING OUT FOR ANYTHING RELATED TO THEIR OWN RESEARCH AREA
@twisteddoodles

Got a story for Feedback?

Send it to feedback@newscientist.com or New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT

Consideration of items sent in the post will be delayed

Raising the bill

How picky should we be about nutrition? The endangered iguanas of the Bahamas are now so jacked on the grapes being offered to them by ecotourists, they are teetering on the edge of the reptile equivalent of diabetes.

A CNN report from the cash-strapped Hakone-en Aquarium in Japan, on the other hand, informs us that its animal guests are more discriminating. Penguins are turning their beaks up at the inferior mackerel they are now being offered by their keepers, while the otters have been observed actually throwing the fish aside – in otter contempt, perhaps? Please send urgent donations of high-end "aji" horse mackerel.

An unwelcome solution

Actually, perhaps we don't need any more fish-in-the-sky stories, now that Sharon Hill, an independent researcher from Pennsylvania, and Paul Cropper, an author from Australia, have solved the "shad rain" mystery.

On 29 December 2021, gizzard shad fell from the sky onto storm-drenched Texarkana, in eastern Texas. Most assumed the unlucky creatures had been syphoned up in a waterspout. But, according to an article in Field & Stream, the skies that day, though thundery, weren't up to sucking up lakes.

Was it a plane? No. There were no unusual cargos in the air. Was it a bird? Ah. Now we come to it. Hill and Cropper talked to local ornithologists and learned that a large number of cormorants had flown slap bang into the storm. Caught in the aerial equivalent of a spin cycle, they may have upchucked all over Texarkana.

Scaling the depths

Might the cormorant become a new unit of measurement for precipitation? Anything seems possible now that no less an organ than *Physics Today* has invited its readers to imagine "atoms so big that each of their protons and neutrons is the size of a blue whale". Reader David Renshaw was especially taken with the idea: by the same logic, electrons can now be represented as rabbits and neutrinos as fruit flies.

... "and rinse"

Wolfing down a late breakfast of half-digested shad is bad for anyone's dental hygiene, so thank goodness there are visionary researchers out there looking to "disrupt oral care technology".

A press release on ScienceDaily offers a breathless portrait of the shapeshifting robotic microswarms "that may one day act as a toothbrush", so long as they continue to obey the diktats of two of their creators, Edward Steager and Hyun Koo at the University of Pennsylvania.

Steager, Koo and their colleagues have found a way to magnetically arrange iron oxide nanoparticle-based microrobots "into antimicrobial bristle- and floss-shaped arrays". They are "considering different means of delivering the microrobots through mouth-fitting devices".

Say it softly, but might there be such a thing as too much disruption? ▮

CLASSIC CARS & MOTORBIKES WANTED!!

Pre-40's, 50's, 60's, 70's, 80's and even 90's

Have you got an old car sitting in your garage or barn going unused?

If the answer is YES please contact us!

TOP PRICES PAID

FREE APPRAISAL SERVICE

All makes and models considered - any condition

Email. **classiccarrestoration2019@hotmail.com**

T. 0800 987 0888 • Mob. 07733 531773

www.classicvehicleswanted.co.uk

Shop at omegawatches.com

SPEEDMASTER SEDNA™ GOLD

Launched in 1957, the Speedmaster earned its nickname in 1969, when it became the first watch worn on the moon. This edition, while retaining the chronograph's classic design elements, features a black step dial and is cased in OMEGA's exclusive 18K Sedna™ gold. The long-lasting rose gold alloy retains its fiery colour and lustre over time, and is named after one of the reddest orbiting planetoids in our solar system. This striking timepiece is also a Co-Axial Master Chronometer, independently certified by the Swiss Federal Institute of Metrology (METAS) to guarantee the highest levels of accuracy, reliability and supreme resistance to magnetism on Earth and in space.

Ω
OMEGA